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PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XII ELVELACEAE[1]

FRED J. SEAVER

(WITH PLATES 17–19)

Since the publication of "The North American Cup-fungi (Operculates)" a number of interesting illustrations have come to hand which were not available for that work. It is the purpose of the writer to publish such illustrations from time to time to supplement the work cited above. Since many of the cup-fungi do not occur in the vicinity of New York City it is difficult to get photographs from fresh material and in such cases it is necessary for the writer to depend upon contributors for illustrations from life specimens. He will greatly appreciate any contribution of this nature which can be furnished, especially when accompanied by dried specimens for confirmation. When these are reproduced full acknowledgment will be given.

ELVELA CALIFORNICA

This species was described by Phillips in 1880 from material collected in California, and was illustrated (Trans. Linn. Soc. II. 1: *pl. 48*) by an excellent drawing. So far as has been observed this species has never before been illustrated from original photographs. The writer has recently received from Miss Maude E. Morris of Seattle, Washington, some excellent photo-

[1] This paper is supplementary to The North American Cup-fungi (Operculates) which was published by the author and issued December, 1928.

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graphs and specimens of this species, the photographs having been made by Mr. C. F. Todd of Seattle, Washington.

This species is very closely related to the writer's species *Elvela umbraculiformis*, (N. Am. Cup-fungi 250, *pl. 41*), our species being characterized by the very much shortened stem so that the pileus appears almost sessile. The length of the stem is not usually a very good specific character and it is possible that further investigation will show our species to be merely a form of the one described by Phillips. We do not have sufficient data at the present time to confirm this view. The largest specimen collected by Miss Morris was reported to be eight inches across. The stem is deeply convoluted, the convolutions forming ridges underneath the pileus. We are greatly indebted to Miss Morris for her contribution of specimens and photographs of this western species.

MORCHELLA CRASSIPES

During the spring of 1929, an unusually large and interesting specimen of the above species was brought to the writer, having been collected by Herman Johnson at Pelham, New York. This specimen was ten inches in height and as indicated by the specific name the base was strongly inflated. While the species is commonly known as "the thick-footed morel" this character is not always evident as it is in this particular specimen, which was photographed by Miss Fleda Griffith of The New York Botanical Garden. In studying this specimen it is noted that although the asci are normally 8-spored occasionally one is found which contains but four spores and these unusually large. The ascus in such cases was found in tact and there were no trace of aborted spores. It is probably that such spores are double nucleated as has been suggested by B. O. Dodge in connection with his studies on the Ascomycetes.

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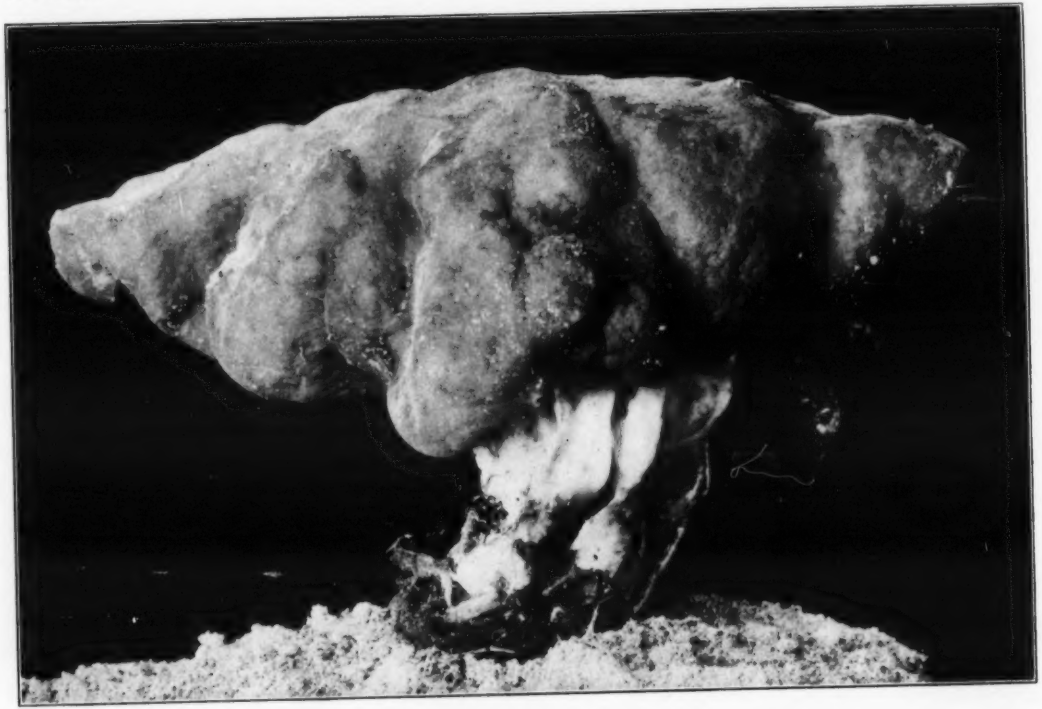
EXPLANATION OF PLATES

Plate 17. *Elvela californica* about two-thirds natural size, with drawings of an ascus with spores and a paraphysis; also diagram of section of stem.

Plate 18. *Elvela californica* about two-thirds natural size. The specimen measured eight inches across.

Plate 19. *Morchella crassipes*, about two-thirds natural size, the specimen measuring ten inches in height; also drawings of asci with spores and a paraphysis.



ELVELA CALIFORNICA

MORCHELLA CRASSIPES

A NEW SPECIES OF CHAETOMELLA ON ROSE

MARJORIE E. SWIFT

(WITH 1 TEXT FIGURE)

Small dark bean-shaped pycnidia were observed growing on a rose twig brought into the pathology laboratory of The New York Botanical Garden in September, 1929. The fungus was cultured and its development followed. Its characters brought it within the genus *Chaetomella* as described by Fuckel (Symb. Myc., p. 401. 1869) as follows:

> Perithecia superficialia, brevissime pedicellata, astoma, ubique sparse setosa. Asci nulli. Stylosporae in sporophororum ramosorum apicibus, simplices, cylindraceae, vel subfusiformes, subcurvatae, quandoque coloratae.

Chaetomella raphigera sp. nov.

Pycnidia dark brown, 126–238 × 98–176 μ (average 178.4 × 132 μ), reniform, with a single ridge or raphe extending lengthwise over the top, scantily setose, astomous, typically superficial and solitary, attached to substratum by a short hyaline stalk; pseudo-parenchymatous wall formed of three tissues of parallel-lying hyphae, the outer consisting of one or two layers of thin-walled light-colored cells, the central of two or three layers of dark brown carbonous cells, and the inner of four or five layers of light-colored thin-walled cells. From the latter tissue grow long slender hyaline hyphae, filling the cavity of the young fruit body with sterile hairs extending upwardly towards the dorsal ridge.

Setae 17.5–77.5 × 2–5.4 μ, tips 5–7.5 μ (average 51.5 × 2.8 μ, tips 5.7 μ), clavate, with straight, bent or hooked tips, 20 to 50 in number and distributed more or less evenly on either side of the raphe, 1–4 septate, dark brown and thick-walled except the tip cell which is thin-walled and light in color; basal cell modified to form a foot somewhat swollen at or near the point of union with the pycnidium wall.

Spores hyaline, frequently pale olivaceous in mass, 4–8.1 × 1.4–3 μ (average 5.46 × 2.1 μ), one-celled, cylindrical to slightly

fusiform, often somewhat allantoid, containing 1 to 3 refractive bodies, borne on slender more or less verticillately branched sporophores arising from a flattened cushion at the base of the pycnidium.

Mycelium mainly submerged, hyaline, branching, septate, 1.5–5 μ, with homogeneous or oily contents; aërial hyphae low-growing, white, aggregating in loose ropes.

On *Rosa* and *Rubus*.

Type specimen collected on *Rosa* sp. in New York in 1929.

DISTRIBUTION: New York and Virginia.

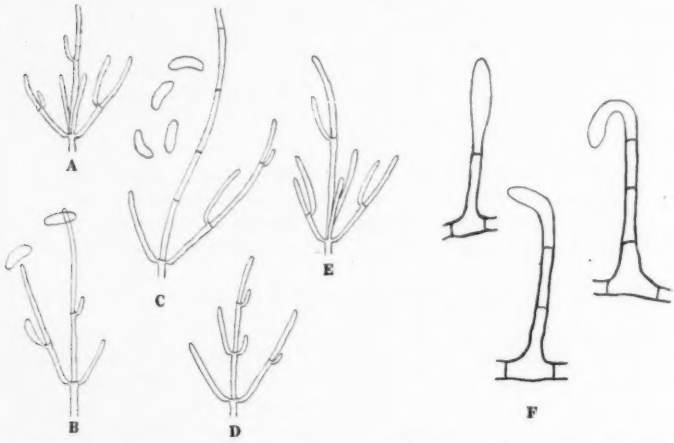


FIG. 1. A–E, sporophores and spores, × 1000. (C, possibly a sterile hypha.) F, types of setae on pycnidium, × 600.

Colonies on corn meal agar are usually concentrically zoned, the mycelial growth well in advance of the fruit bodies which appear to the naked eye as small dark brown or black dots distributed evenly in the center of the culture, or following roughly the concentric zones of the mycelium. Mycelial growth, as well as pycnidial formation, is much more abundant on dextrose and potato dextrose than on corn meal media.

The pycnidia have been observed to be typically solitary, but they may occur in small groups of three or four attached to the substratum by the same stalk. As noted, a single low ridge or raphe along the top divides the pycnidium more or less symmetrically. However, a number of three-sided fruit bodies have

been seen, with a ridge separating the three surfaces, giving the pycnidium a somewhat trihedral appearance from above.

Spore release might be expected to occur through a splitting of the pycnidium along the suture. When a cover glass is tapped gently the fruit body under it breaks in an even line along the ridge, but when a slightly greater pressure is applied an irregular break occurs. No natural splitting has been observed even in old cultures, but dry fruit bodies often appear to be sunken along one side of the ridge, transforming the pycnidium into an inequilateral or concave-convex body.

Table I lists the described species of *Chaetomella* with their spore measurements or other distinguishing features, and the recorded substrata.

TABLE I. SPECIES OF CHAETOMELLA

Species	Spore Measurements, etc.	Substratum
C. Andropogonis Cooke & Ellis	6×5μ; setae rigid, 250μ	*Andropogon*
C. Artemisiae Cooke	8–10×4μ	*Artemisia*
C. atra Fuckel	12–15×2–3μ	*Phragmites, Carex, Arundo* and maize
C. atra var. *bambusina* Sacc. & Scalia	13–15×2–3μ	*Bambusa*
C. atra var. *charticola* F. Tassi	14–16×2.5–3μ	Old paper
C. atra var. *lignicola* Sacc.	12–15×2.5μ	Bark
C. beticola Oud.	10–12×6–7μ	*Beta*
C. brachyspora Sacc. & Speg.	5–6×3μ, dark; pycnidia depressed	*Catalpa*
C. Brassicae (Schw.) Starb. (*Sphaeria Brassicae* Schw.)	5–10 μ	*Brassica*
C. eucrypta Cooke & Mass.	16×10μ	*Knightia*
C. furcata Cooke & Mass.	10–11×8μ	Coriaceous leaves
C. horrida Oud.	5.5–7×3.5–4μ; setae branched	*Betula*
C. longiseta Delacr.	6×4μ; setae rigid, pointed	*Pisum*
C. Melandryi G. Frag. (*Amerosporium Melandryi* (G. Frag.) P. & S.)	9–13×3–2.5μ	
C. oblonga Fuckel	11×2μ	*Rosa*
C. oblonga var. *major*	11×2μ; pycnidia large	*Quercus*
C. perforata Ellis & Ev. (*Acanthostigma occidentale* (Ellis & Ev.) Sacc.) (*Venturia occidentalis* Ellis & Ev.)	20–25×4–5	*Cirsium*
C. raphigera Swift	5.5×2μ	*Rosa*
C. raripila (Mont.) Sacc. (*Chaetomium raripilum* Mont.)	13–14×2μ	*Polygonum*
C. Sacchari Delacr.	10–18×9μ	*Saccharum*
C. Stevensoni Ellis.	19–26×2.5–3μ	*Dentaria*
C. tortilis Delacr.	12.5×6.5μ	*Populus*

Chaetomella oblonga collected on *Rosa rubiginosa* by Fuckel in Austria (Symb. Myc. p. 401, 1869) is the only one of these which resembles the above-described fungus in any material respects, but several important differences distinguish the two forms.

First, the spore measurements of *C. oblonga* are 11 × 2 μ. Those of the present fungus are 4–8.1 × 1.4–3 μ (average 5.46 × 2.1 μ).

Examination of No. 1962 of *C. oblonga* in Fungi Rhenani in the Harvard University Herbarium, was very kindly made by Dr. W. H. Weston through the courtesy of Professor Thaxter. The fifty spores measured ranged from 7 to 11.3 μ in length by 1.5 to 2 μ in width. Although the length of these spores is slightly less than that recorded by Fuckel, there is still no question that the dimensions are distinctly different from those of our species found on rose in New York.

Second, the setae of *C. oblonga* are described as rigid and evenly colored. Curved and hooked hairs, although not numerous on the pycnidia of the fungus described in this paper, are sufficiently noticeable to attract attention. The swollen light-colored tips could not escape mention (FIG. 1, *F*).

Third, the most striking feature of the pycnidium upon superficial examination is the ridge or raphe along the top. This was apparently not present in *C. oblonga*.

In view of these differences, the fungus described herein is believed to be a new species, and is given the name *Chaetomella raphigera*, because of the ridge-like marking extending over the dome of the pycnidium.

A *Chaetomella* was found on rose and blackberry by Dr. C. L. Shear and Dr. B. O. Dodge at Rosslyn, Virginia, on several occasions from 1920 to 1926. Sections of the material made at that time were loaned the writer for examination, and measurements indicate the identity of the New York form and that found in Virginia. Certain features of *C. raphigera* are described in greater detail elsewhere in this journal by Dr. Dodge, to whom acknowledgment is made for material suggestions in the preparation of this paper.

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DEVELOPMENT OF THE ASEXUAL FRUCTIFICATIONS OF CHAETOMELLA RAPHIGERA AND PEZIZELLA LYTHRI

B. O. Dodge

(With Plates 20 and 21)

Mycologists now seldom use the term pleomorphic in referring to a fungus which has different spore forms in its life cycle. Medical mycologists however still use the term in a rather restricted sense. When *Trichophyton gypseum*, for example, changes its habit of growth in culture to produce a whitish, fluffy cottony, more or less sterile mycelium they say the culture has gone pleomorphic. On Sabouraud's conservation medium their fungus is more apt to remain stable and so is kept in its original form for study. Once it has "become pleomorphic" on any medium it is said not to revert to its original type when transfers are made. Such behavior as this mycologists would perhaps call mutations or saltations. Recent mycological literature is full of examples of races of fungi which are unstable and inclined to "mutate" especially when grown on certain media. Prospects for further important contributions on this subject are encouraging for the reason that plant pathologists as well as mycologists are giving their attention more and more to biologic or physiologic races, their origin and nature. It is being realized that the question regarding the stability of a race,—whether the variations or changes referred to above are permanent, hereditary and genotypic, can best be determined by breeding the various strains. This means that they must be made to reproduce sexually or in some way which involves nuclear and cytoplasmic fusions followed by reduction divisions, thus giving the opportunity for orderly segregation, if there be such in any particular case. The subject of the present paper is somewhat apart from this question, yet it has a direct bearing on it as illustrating a curious effect or influence of the culture medium on the type of fruit body formed.

Pezizella Lythri (Desm.) Shear & Dodge [1] is one of the most widely distributed and much named spot disease fungi. Since the publication of the paper the writer has observed at various times the degree of pathogenicity of the fungus on different hosts. As a rule it is not one of the destructive spot diseases. It is however, occasionally very severe in its attacks on the host. Certain wild blackberries and dewberries in Florida and Georgia were seen to be practically defoliated as the result of attacks by this species. At one place in the mountains of North Carolina where *Galax* and the rare *Shortia* were growing abundantly their leaves were badly scarred and spotted. Figures *A* to *C* in plate 20 show the characteristic types of injury. The large black pycnidia of the *Ptilidium* or *Sclerotiopsis* stage were very abundant, scattered over the areas killed by the parasite. *Pezizella Lythri* is one of those so-called "pleomorphic" forms which develops two different kinds of asexual fructifications both of which take on various aspects depending on the species of host attacked, and other environmental conditions. This peculiarity may account in part for the pycnidial stage having been referred to *Ceuthospora*, *Leptothyrium*, *Sporonema*, *Sclerotiopsis* and *Ptilidium* under at least 13 specific names. The sporodochial stage has been placed in 7 different genera under at least 10 other specific names. Shear and Dodge (l.c., *pl. 8*) pointed out that this latter stage is especially apt to vary with conditions. The delicate flesh-colored patellate *Hainesia* sporodochium often becomes, when grown on apple fruit, a black pycnidium-like structure with a wide ostiolar opening through which is extruded a mass of spores simulating a cirrus (l.c. *pl. 8, fig. 6*). Although the *Ptilidium* (*Sclerotiopsis*) and *Hainesia* spore forms may be found side by side on a leaf or stem, the one never is a modification of or a development from the other. They are distinct morphological units represented by a separate set of genetic factors.

During the time studies on *Pezizella* were being carried on the writer had in culture a species of the form genus *Chaetomella* collected on rose and also on wild blackberry. The fungus is

[1] Shear, C. L., and Dodge, B. O. The life history and identity of "*Patellina Fragariae*," "*Leptothyrium macrothecium*," and "*Peziza Oenotherae*." Mycologia **13**: 135–170. 1921.

described as a new species, *C. raphigera*, by Miss Marjorie E. Swift on another page in this issue of Mycologia. Its sexual stage is unknown and no species of the genus has been connected with a perfect stage. Following the development of the asexual fruit bodies of *Pezizella Lythri* and *Chaetomella raphigera* one finds certain striking resemblances as well as marked differences. The reader is referred to the paper previously cited and to a later one by the writer [2] where a full discussion of the development and morphology of the three kinds of fructifications of the former species will be found illustrated.

Cultured on blackberry stems in tubes the pycnidium of *Chaetomella* originates beneath the epidermis. A mound of tissue without particular form or orientation of hyphal elements breaks its way through the epidermis. In cultures on agar the mycelium forms a tough mat or skin-like layer over the surface. At the point of origin of a pycnidium a foot structure, enlarged above, first develops. From this point on, the stages in pycnidium formation on agar and on stems are much the same. From the top end of the stalk there begins an upward growth of slender colorless hyphae ranging outward and upward, then drawing together at their tip ends to form an elongated dome (PLATE 21, *A*). The ends of the hyphae come together not at a point, but, owing to the form of the growing fruit body, in a line which extends lengthwise over the top of the dome, forming a sort of suture which becomes more distinct as the pycnidium reaches maturity (PLATE 20, *E* AND *G*).

During this interval the stalk continues to thicken especially above where it spreads out. The body of the young pycnidium is now plainly raised above the surface of the substratum. Next, one sees in section a differentiation of the slender upward growing hyphae, previously mentioned, into two distinct regions, an outer and an inner (PLATE 21, *B*). The outer tissue consists of some ten or a dozen layers of elongated narrow cells tending to become brick-shaped. This is to become the wall which will undergo further differentiation. The space within the bounding wall is filled with the long slender undifferentiated hyphae whose free tips all but come together beneath the ridge of the dome wall.

[2] Dodge, B. O. Origin of the central and ostiolar cavities in pycnidia of certain fungous parasites of fruits. Jour. Agr. Research **23**: 743–759. 1923.

Except perhaps for a small opening just beneath the ridge there has been as yet no opening corresponding to a pycnidial cavity.

Next begins a differentiation of the wall tissue. Long before the pycnidium has reached full size the comparatively short and stiff setae (PLATE 21, *C*) which characterize this species have begun to grow out from the outer layer of wall cells. This outer wall is two or three cells thick and the cells remain hyaline for a long time. About the time the pycnidium is attaining its full growth, the middle wall begins to turn brown. It consists of two or three layers of thick-walled brown cells (PLATE 21, *D*). This layer finally cuts down beneath the pycnidium and forms the line of separation when the body of the mature pycnidium is detached from its stalk, which can be done readily. Along a line right beneath the ridge of the dome the inner row of these thick-walled cells appears to be wanting and the cells of the outer row buckle outward. This is, no doubt, a provision for a line of weakness along which the wall may rupture in spore discharge later.

When we consider that the spore-bearing part of the pycnidium is readily dislodged from its stalk and that it is armed with stout stiff setae which are often hooked, it looks as though nature had provided a way for the whole fruit body to become attached to insects for transportation, after which by dehiscence the spores would be spread locally.

The third and inner wall of the pycnidium consists of about four or five layers of small thin-walled cells which line the cavity completely except for the basal sporogenous cushion. It is from these cells at the sides and also well toward the top one sees some thin colorless hyphal threads extending into the cavity. Spore formation does not begin usually until the pycnidium has become colored dark brown. Some of the hyphae ranging upward from the basal cushion undergo disorganization and furnish quantities of degeneration products which appear like oil droplets in crushed mounts. The minute bodies seen in figure *C* of plate 21 are the cut ends of these thread-like hyphae which completely fill the central region. No spores have been formed up to this time. Figure *B* on this plate is of a section through the center of a much younger pycnidium and shows these

hyphae in longitudinal view. Similar hyphae are seen in figure *F* which is of another type of structure to be described presently. While in a mature pycnidium the sporophores are rather short filaments, once or twice branched in incomplete whorls, some spores or spore-like bodies are formed precociously from these long filaments which are beginning to break up. In an old pycnidium the cavity is quite filled with spores and one sees very few filaments remaining. The sporogenous tissue at the base is usually a flat cushion (PLATE 21, *E*). Occasionally it appears rather low conical in section, however.

It has been noted (p. 170) that *Pezizella Lythri* develops two kinds of asexual fructifications, one of which is a fleshy patellate sporodochium. When one grows *Chaetomella* in culture on a very soft agar well supplied with nutrient, or on blackberry stems in tubes tightly plugged and containing water at the bottom to provide a saturated atmosphere, pycnidium formation is sometimes abnormal. That is, instead of forming a reniform dark colored closed pycnidium, the spore bearing structure develops into a beautiful white patellate sporodochium with a crenulate margin bearing the straight or hooked setae, now uncolored (PLATE 20, *H–K*, PLATE 21, *F*, *G*). Such structures are open from the first and spore formation begins rather early. The spores accumulate in a mass or mound (PLATE 20, *K*) and in this stage, except for the setae, resemble exactly the *Hainesia* form of *Pezizella* described by Shear & Dodge (l.c. *pl. 8, fig. 2*). By manipulating the conditions as to humidity, one can stop spore formation in what would have otherwise been an open type and induce the formation of a wall up over the top of the structure which will then go on to maturity as a normal pycnidium, except that it will not have as many setae at the top of the dome. The central ridge likewise will not be distinguishable.

Sometimes, but not always, when the normal pycnidium, as well as the open type, develops beneath the surface of the agar, no setae are formed. On the other hand, one can often find setae arising indiscriminately from hyphae all over the surface of the agar without regard to the beginnings of fruit bodies.

The writer[2] has described the formation of the pycnidial cavity in three different types of pycnidia. *Chaetomella* illus-

trates a fourth type where the central region is filled from the first with free-growing hyphal elements not organized into a compact tissue. Space for spore formation and storage is provided by disorganization of these central filaments and, as a result, predigested food is provided for spore development.

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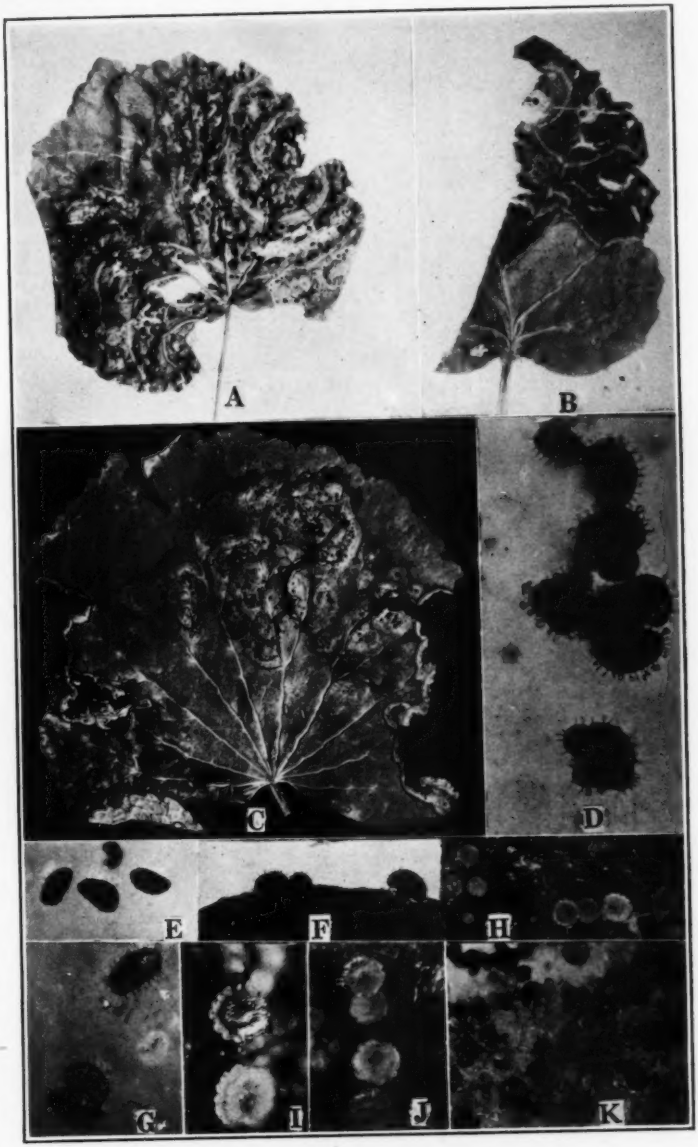
EXPLANATION OF PLATES

PLATE 20. *A* to *C*, *Pezizella Lythri*; *D* to *K*, *Chaetomella raphigera*

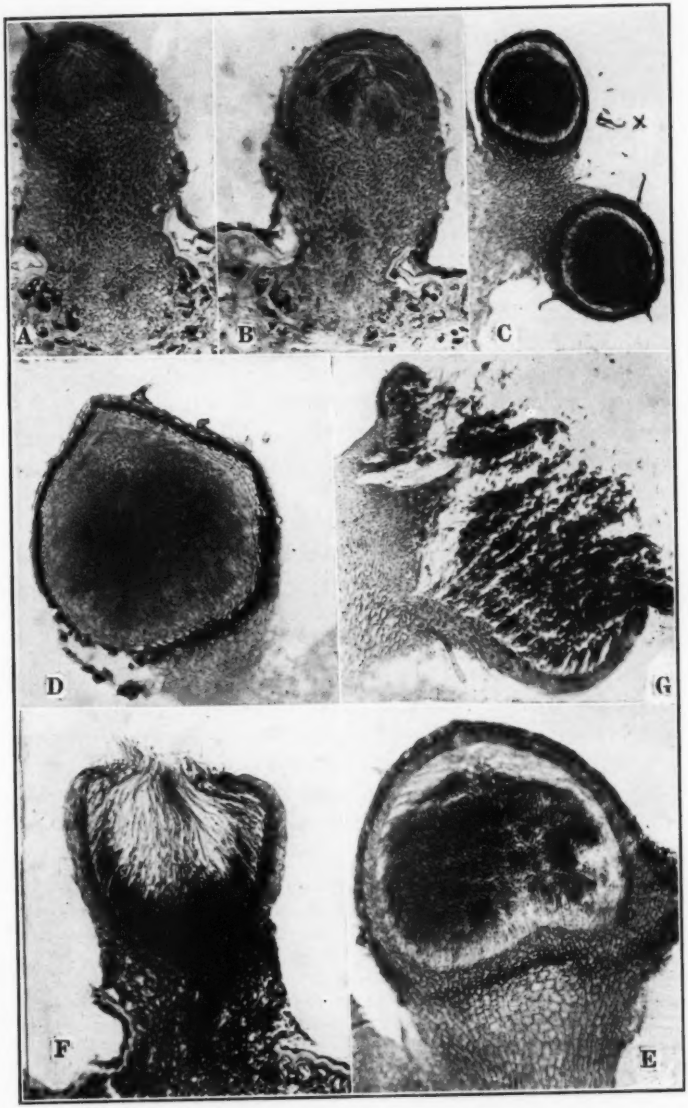
A, *Ptilidium* (*Sclerotiopsis*) stage of *Pezizella Lythri* on leaf of *Galax*. Photograph natural size from dried specimen; *B*, leaf of *Shortia* showing destructive effect of infection by this fungus, slightly enlarged; *C*, leaf of *Galax* showing characteristic type of leaf spot on living leaf; *D*, pycnidia of *Chaetomella raphigera* grown on agar. Note setae bearing droplets of water; *E*, pycnidia showing raphe over the dome; *F*, showing stalk on pycnidium; *G*, pycnidia just beginning to turn brown, raphe marking and bristles distinct; *H*, *I*, and *J*, white patellate open types of fructifications developed on soft agar. Spore masses were removed before photographing to show crenate margins and setae, visible in I above; *K*, masses of spores on open types. Black bodies are closed types induced to form later by drying agar.

PLATE 21. *Chaetomella raphigera* Swift

A, Vertical section through very young pycnidium slightly to one side of central axis, showing subepidermal origin, stalk, and free-growing hyphae in the pycnidial cavity. Base of seta at upper left; *B*, section through center of young pycnidium showing differentiation into wall tissue and central cavity filled with slender hyphae converging beneath the dome; *C*, section through two pycnidia arising from a branched stalk. Pycnidial wall differentiated into three tissues. Broken setae show on lower pycnidium and curved seta at *X*; *D*, section showing three wall-tissues and origin of two setae which were broken away in sectioning; central cavity filled with thread-like hyphae cut ends of some of which can be seen. Spore formation just beginning; *E*, similar to *D* but shows nature of stalk tissue which is being cut off by sclerotized middle-wall tissue; *F*, section of open type of fructification grown on blackberry stem in tube under humid conditions. Wall cells will not be sclerotized. The structure is open from the first and will remain so. Stalk apparent. Central region shows thread-like hyphae ranging upward. Conidia being formed from sporophores at base of cavity; *G*, open type of fructification grown on soft agar. A patellate sporodochium, open from the beginning. This is one arm of a double fruit body similar to the one shown in *C* except that it is an open type; note seta left center below. Short branched sporophores have developed masses of spores. Compare with figs. *H* to *K*, plate 20.



PEZIZELLA LYTHRI AND CHAETOMELLA RAPHIGERA



CHAETOMELLA RAPHIGERA

THE RELATIONSHIP BETWEEN THE BLUE-STAINING FUNGI CERATOSTOMELLA AND GRAPHIUM

CAROLINE T. RUMBOLD

The question of whether *Graphium* is an imperfect stage of a *Ceratostomella* that stains the sapwood of hardwoods and of softwoods has caused some controversy. In the United States the two organisms are generally assumed to be distinct, independent fungi, whereas in Europe a relationship is recognized.

In this country Von Schrenk,[1] who was the first to report a fungus blue-staining pines, described *Ceratostomella pilifera*, from cultures made by Hedgcock, without mentioning *Graphium* either on the host trees or in the cultures. Hedgcock,[2] continuing the study of the blue-staining fungi in pure culture, always found that *Ceratostomella* and *Graphium* could be separated by careful isolation methods. The many systematic descriptions given in Saccardo of *Ceratostomella* collected in the United States fail to mention *Graphium* as an imperfect form of the fungus. Rumbold[3] cultured some fungi found in blue-stained wood, among which was a *Graphium* isolated from a deeply stained board of red gum (*Liquidambar styraciflua*). In contrast with the usual results, some of the cultures started from this *Graphium* developed perithecia after they were about three weeks old, but unfortunately when this work was carried on the time available was insufficient to investigate satisfactorily the

[1] Hermann von Schrenk. "The 'Bluing' and the 'Red Rot' of the Western Yellow Pine with Special Reference to the Black Hills Forest Reserve." Bureau of Plant Industry, U.S.D.A. Bul. 36, 1903.

[2] Geo. G. Hedgcock. "Some Wood Staining Fungi from Various Localities in the United States." Jour. Myc. **12**: 204–210. 1906. "Studies upon some Chromogenic Fungi which Discolor Wood." Annual Report of the Missouri Botanical Garden **17**: 59–114. 1906.

[3] Caroline Rumbold. "Uber die Einwirkung des Säure- und Alkaligehaltes des Nährbodens auf das Wachstum der holzzersetzenden und holzverfärbenden Pilze; mit einer Erörterung über die systematischen Beziehungen zwischen *Ceratostomella* und *Graphium*." Naturwissenschaftliche Zeitschrift für Forst- und Landwirtschaft **9**: 429–467. 1911.

possibility of a relationship between the *Graphium* and the *Ceratostomella*. The conclusion from the evidence heretofore available thus is that in this country the two fungi grow independently of each other; it apparently would be an exception if a connection were found. Further evidence of a confirmatory nature will be presented in this paper.

In Europe Münch [4] was the first worker to study blue-stain fungi in pure culture. He described and named *Ceratostomella Piceae* and *C. cana*, Pyrenomycetes whose cultures produced a *Graphium* as a conidial form. He considered the *Graphium* identical with Corda's *Graphium penicillioides*. MacCallum [5] found and described *C. Piceae* in England. Lagerberg, Lindberg, and Melin [6] collected *C. Piceae* in different regions in Sweden. They observed that, when cultivating this fungus from ascospores, the culture always produced *Graphium* stalks before it developed perithecia. Often the perithecia failed to appear if the culture was weak.

During the four years that the writer has been studying cultures of the blue-stain fungi of the United States, a fairly large number of samples of blue-stained hardwoods and softwoods has been collected from various parts of the country. The record of the cultures from these specimens shows that they produced a single fungus, either a *Graphium* or a *Ceratostomella*, fully as often as they developed *Graphium* and *Ceratostomella* together. The two could be isolated and cultured for generations as separate fungi. In other words, the species of *Graphium* in general are not imperfect stages of *Ceratostomella*.

In one case only has the author seen a connection between the two fungi; a *Ceratostomella* that had a *Graphium* as a conidial form of fruit was found growing on a rough-surfaced birch board (*Betula* sp.) 1½ inches thick collected in a lumber yard in Wisconsin. For three years an effort was made to separate the two

[4] Ernst Münch. "Die Blaufäule des Nadelholzes." Naturwissenschaftliche Zeitschrift fur Forst- und Landtwirtschaft **5**: 531–473. 1907; **6**: 32–47, 297–323, 1908. 33 figs.

[5] B. D. MacCallum. "Some Wood Staining Fungi." The British Mycological Society Transactions **7**: 231–236. 1922.

[6] T. Lagerburg, G. Lindberg and E. Melin. "Biological and Practical Researches into Bluing in Pine and Spruce." Svenska Skogsvardsforeningens Tidskrift **2**: 145–272, 561–739, 88 figs. 2 colored plates. 1927.

forms, *Ceratostomella* and *Graphium*, from this specimen by means of the poured-plate method. Ascospores were sown on malt agar in Petri dishes and the young colonies were transferred to fresh Petri dishes before fruits had appeared. *Graphium* stalks always appeared first and later *Ceratostomella* perithecia. One could not be sure, however, that the colonies started from ascospores only for, since the spores of *Ceratostomella* have a gelatinous covering, it is possible foreign conidia may have been sticking to them. These spores are too small to be observed until they have swelled and germinated. During the summer of 1927 [7], 23 single-spore cultures were made. After the ascospores had germinated secondary conidia developed; then *Graphium* fruits appeared. Every one of the 23 lines produced *Graphium* stalks. In a month 4 out of the 23 lines produced perithecia. When three months old the *Graphium* heads in the cultures of these 4 lines were dry and the *Ceratostomella* fruits fresh. Eight months after the cultures were started 9 of the *Graphium* lines were becoming sterile, that is, they no longer developed *Graphium* stalks. This behavior is similar to that described by Münch for *C. Piceae* and *C. cana*, and by Lagerburg for *C. Piceae*.

A possible reason is suggested for this fact that only 4 out of 23 of the single spore cultures produced perithecia. It may be that the cultures which produced both *Ceratostomella* and *Graphium* came from binucleate spores and the other 19 from uninucleated spores which were plus or minus and thus uncapable of perithecial formation. This could be tested by mixing some of the 19 lines.

It is an interesting phenomenon that this *Ceratostomella* and *Graphium* strain has been fruiting on malt agar slants for more than three years, during which the cultures have looked normal. The method of starting new cultures has generally been to gather the globules of ascospores from the tips of the perithecia on a platinum needle and then transfer them to fresh agar medium.

[7] The work of making the single spore cultures was done by Miss Beatrice Nevins, graduate student in botany, University of Wisconsin.

Ascospores from a single perithecium were separated by shaking in malt solution and left over night in the solution. They were then sown on gelatin plates, where they were found to have germinated. Isolated spores were removed to Van Tieghem cells and there grown further under observation before acceptance as true single spores.

When *Graphium* conidia were used as the inoculum, *Graphium* stalks appeared shortly after the conidia were sown. Before the young culture produced perithecia, *Graphium* conidia were again transferred to fresh agar slants. Apparently a *Graphium* culture unmixed with *Ceratostomella* was procured, but the cultures after about the fifth generation ceased to fruit, that is, to produce *Graphium* stalks. The mycelium was cream-colored. This whole experiment was repeated several times. The strain when perpetuated through *Graphium* conidia seems unable to continue growth in artificial culture.

The formation of the fruits was influenced by the condition of the substratum. In agar slants the top or driest portion of the culture developed *Graphium* while the middle of the slant, which is moister, was usually occupied by *Ceratostomella* perithecia. The mycelium was light-colored when young, and gray, brown, or black where perithecia had formed.

PERITHECIA

The perithecia are similar to those of *Ceratostomella pilifera* (Fries) Winter. Although the bases have brown septate hairs scattered over them, they themselves are black. In shape each perithecium is globular, and often is flattened at its base. Their diameters average 148 μ [8]; with a sextile range for those under favorable circumstances (at the middle of the slant), of 136 to 172 μ; their average height is 140 μ, sextile range 136 to 172 μ. The dimensions of their beaks are as follows: Average length, 1156 μ; sextile range 1040 to 1403 μ; average diameter at the base. 39 μ and at the tip 9 μ. In addition, the hyaline bristles at the tip of the beak are 6 to 30 μ long. Asci are 6 μ by 5 μ, while the slightly curved ascospores average 5 μ by 2 μ. The secondary conidia resemble those found in *C. pilifera* cultures.

GRAPHIUM

The black bases of the *Graphium* stalks that develop a few days after the ascospores germinate shade into brown near the tips of the stalks. The ends of the hyphae that bear the hyaline

[8] The averages reported in this paper are each based on 20 or more measurements, from several different cultures, and representing top, middle, and base of slant. The sextile range is that remaining after the highest sixth and the lowest sixth of the values have been discarded.

conidia are white when young, but are cream-colored by the time the perithecia are forming. This *Graphium* resembles *Graphium penicillioides*, which Münch associates with *Ceratostomella Piceae*.

The stalks average 645 μ in length, with a sextile range of 442 to 885 μ; the widths of the stalks average 48 μ and sextile range 20 to 89 μ. The primary hyaline conidia average 3 μ by 1 μ.

A common sight in cultures is aerial strands of mycelium on which *Graphium* stalks intermingle with secondary conidiophores. Münch illustrates this formation in his description of the *Graphium* connected with *Ceratostomella Piceae*. Hedgcock [2] remarks about his own *Graphium* cultures, "It is also quite probable that in all species of *Graphium* the primary conidia are formed in the head precisely as the secondary conidia are formed in the open and that the two forms of conidia are morphological equivalents. In most of the species studied many graduations were found between a head on a stalk of a single colored filament and heads on stalks of two to many filaments."

SUMMARY

The connection between *Ceratostomella* and *Graphium* shown in cultures in which both appear suggests the possibility that *Graphium* may be in a state of evolution; perhaps at one time it regularly formed the imperfect stage of *Ceratostomella*. In the United States the cases in which this connection can be demonstrated seem to be few; in Europe they are more frequent.

The fungus that produces both *Ceratostomella* and *Graphium* is regarded by the writer as a strain of *Ceratostomella pilifera* (Fries) Winter, which is one of the commonest blue-staining fungi in lumber yards. Although there are many strains of this species that vary in minor details, such as the size and the shape of their perithecia and their habits of growth on and in the sapwood of hardwoods and of softwoods, the strains are not so different that they should be classified as distinct species. A careful study of the fungi grown under cultivation has convinced the writer that there is no line that can be drawn between one strain and another.

OFFICE OF FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
IN COÖPERATION WITH THE
FOREST PRODUCTS LABORATORY

A NEW VARIETY OF ACROTHECIUM OBOVATUM

BAILEY K. ASHFORD AND RAFFAELE CIFERRI

(WITH 2 TEXT FIGURES)

Origin of strain: A saprophyte of the human skin.

Collection number: 1519,[2] Ashford.

Cultural and morphological characteristics: On Sabouraud's proof agar, the colony is at first whitish, afterwards whitish with gray shading. The border is delicate, evanescent, with creeping vegetative hyphae. The surface has a woolly appearance and is irregularly furrowed. It presents at times drops of water of condensation which are colored black or dark-brown. Its development is quite slow and normally it fails to extend over the entire surface of the medium. It grows easily on any kind of sugar or peptone-sugar media always with characteristics similar to those described for cultures on Sabouraud's agar. The mycelium is composed of very abundantly and irregularly branched hyphae which are septate, much twisted, and, especially on the surface, where the felt-like duvet is formed, it is of a quite even caliber and sub-hyaline or even hyaline. The branching of hyphae is not uniform; frequently the branches are lateral, coming off in pairs, one on each side, or alternately (FIG. 2, *a*). The hyphae which are found in the upper layers of the medium or which adhere to the surface are frequently composed of almost hyaline, toruloid articles which can be interpreted as chlamydospores. They are usually intercalary, rarely terminal. This mycelium has a greater caliber than that of the surface type. The moniliform chains are of very varied aspect. Without explaining in detail its morphological aspect, which is similar to that described in cultures of many Dematiaceae, we refer the reader to figure 2, *b*, where some of them are sketched. Frequently, although not uniformly, the deep mycelium and that attached to the surface branches and becomes densely entangled forming a loose plectenchymatic structure. Not unusually

mycelial rhizoides in the form of nodular bodies are seen, with multiple branches which proceed from one sole point, or from a short slip of a primary hypha which grows down into the agar or spreads out superficially. One of these rhizoid elements is depicted in figure 2, *c*.

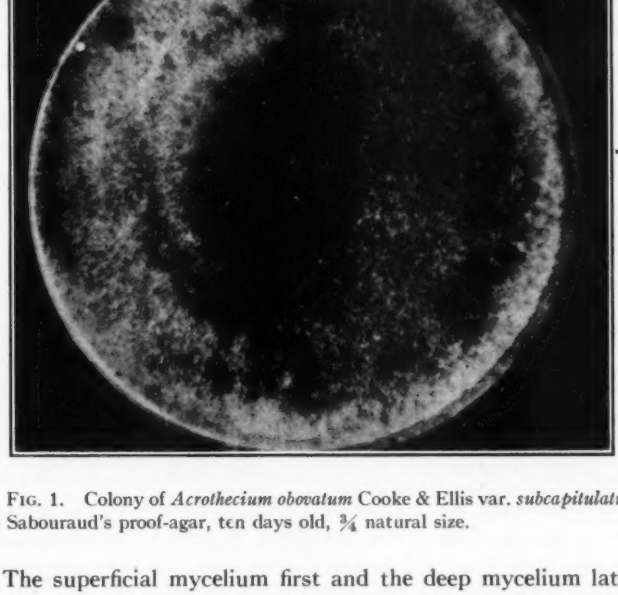


FIG. 1. Colony of *Acrothecium obovatum* Cooke & Ellis var. *subcapitulatum*, on Sabouraud's proof-agar, ten days old, ¾ natural size.

The superficial mycelium first and the deep mycelium later, produces conidiophores, although more abundantly the first than the second. They are simple or branched, short or long, but the simple and long variety predominate and the branches are generally fertile. They are straight or irregularly sinuous; rarely twisted; prostrate or semiprostrate, rarely erect; subhyaline highly septate. Their caliber is approximately from 2 to 3 microns. Their base is not bulbous or spherical, nor is the free extremity, which, however, may at times be almost imperceptibly swollen.

The conidia are acrogenous but on rare occasions can be found not at, but near the end of the hypha. They are solitary or

vertisillate but their number is extremely variable. In certain zones of the culture the unisporous conidiophores predominate and in others the polysporous, the latter, however, being less common than the former. But we ought to add that the production of conidia is not very abundant. The *Verticillia* are compound consisting of from two to five elements, usually from two to three. Their shape is from oval or sub-oval to elliptical, rarely subclavate or fusiform, and, in the latter case, in certain instances, scythe-shaped. Their color is a more or less dark smoky-brown. If the conidium is uniseptate, both compartments may have the same color, or one, generally the apical, is of a lighter color, the other being darker. If the conidium has two or more septa the central cell is frequently darker than the basal and apical. This fact has been already pointed out in the description of other species of this genus. The number of the septa varies from none to three, but in well-developed conidia they are usually two or three, rarely one. Their size varies between fairly wide limits but is generally from 20 to 28 by 6 to 8 microns. The episporium is normally well in evidence and very little if at all constricted at the site of the septa. These septa are straight or, more frequently, curved. The insertion of the conidia upon the conidiophore is direct.

The fructification of this fungus is generally scanty, even in media which are especially favorable. The fertile layer is usually that in direct contact with the agar. The conidia appear at first in clavate form at the extremity of a hypha or its branch, and are subhyaline and continuous; they grow rapidly, becoming darker and forming their septa. The mature conidia germinate with some difficulty, either in hanging drop or in microculture on solid media. They generally emit a germinative tube from the central compartment, more rarely two, one from each one of two compartments that are near each other.

SYSTEMATIC POSITION

This fungus belongs to the Dematiaceae Macronemeae Acrothecieae, and, in this tribe, to the genus *Acrothecium* Preuss (**6**, **7**) emend. Saccardo, p.p. nec Corda.

The history, the signification, and the nomenclature of this genus is not yet clear. A good study of it has recently been

made by Mason (**5**) from the standpoint of *A. lunatum* Wakker and summarized by one of the authors (**1**), in studying *A. nigrum*. In the latter work the conclusions of Mason were temporarily accepted as valid, with the genus and its present designation, and to these works we refer the reader for more details.

As one of us had already studied the organism, (**1**) in the case of *A. nigrum*, our strain here under consideration offers in culture notable variations, approximating now *Brachysporium* Sacc., now *Spondylocladium* Mart., now *Napicladium* Thüm. Besides, the uniseptate conidia approximate *Cordana* Preuss, and, the continuous conidia, *Acrotheca* Fuckel.

Among the species belonging to the sub-genus *Eu-Acrothecium* Sacc. with dark conidia, the species which most resembles our own is *A. obovatum* Cooke & Ellis (**2**) which lives on the branches of the tree or in the wood, this cosmopolitan species being known in Northern, Central and Southern Europe and in North America.

However, there exist some differential characteristics, although small and of secondary importance, which could be attributed to the influence of the habitat on our strain (culture on artificial media) and to that working upon the species of Cooke and Ellis who only made their study of the organism as it lay in its normal habitat, wood, and who made no cultures. In order to summarize clearly the differential characteristics between our strain and that of *Acrothecium obovatum* as defined by Saccardo (**8**), Lindau (**4**) and Ferraris (**3**), we have constructed the following table:

Acrothecium obovatum Cooke & Ellis	*Strain* **1519** [2]
Black tufts.	White tufts with grayish shading.
Conidiophores 150×5 microns.	Length of conidiophores very variable.
Conidia in groups of from three to five.	Conidia isolated, or in verticillate groups of two or three, rarely to five.
Conidia bi-septate, somewhat constricted at site of the septa.	Conidia bi-septate; sometimes none; rarely three, not constricted at site of septa, with a darker color in the intermediate compartment.
Conidia sub-ovoid; 18 to 20 by 7 to 8 microns.	Conidia sub-ovoid but variable, even forming scythe-shapes; 20 to 28 by 6 to 8 microns.

The other characteristics are identical except the microscopic not possible to compare.

On account of these differences it seems justifiable to create a new variety *ad interim* which has only a temporary value. A monographic study of this genus, which would make comparative studies on the species on natural media and the relative importance of variations of these species in different media and under varied conditions, will definitely determine the systematic value of this variety.

FIG. 2. *Acrothecium obovatum* Cooke & Ellis var. *subcapitulatum*. (*a*) Hypha with its branches; (*b*) Serial intercalary chlamydospores; (*c*) A nodular body composed of rhizoides; (*d*) Different forms and types of conidia and conidiophores. Sketched by camera lucida. Object .4, Ocular .25 B. & L.

We present the diagnose of the new variety:

Acrothecium obovatum Cooke. & Ellis, var. **subcapitulatum** Cif. & Ash, var. nov.

Differs from type by the color of the colony (white with gray shading); condiophores very variable in length; two to three verticillate conidia, rarely five, generally bi-septate, rarely from one to three septa or even none; conidia not constricted, central compartment darker than the others, ovoid, elliptical, even clavate, rarely fusiform or scythe-shaped, from 20 to 28 by 6 to 8 microns.

Habitat: Saprophyte of human skin, April 15, 1928, San Juan, Porto Rico, recovered from skin by Dr. Bailey K. Ashford.

Summary: A discussion of the cultural and morphological

characteristics of a new variety of *Acrothecium obovatum* Cooke & Ellis.

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LITERATURE CITED

1. **Ciferri, R.** Champignons des tropiques américaines de l'homme et des animaux. (In press.)
2. **Cooke, M. C., & Ellis, J. B.** New Jersey fungi. Grevillea **5**: 49–55. *pl. 80, 81.* 1876. (P. 50. *pl. 80, f. 13.*)
3. **Ferraris, T.** Fungi italica cryptogama. Pars I: Fungi. Hyphales. 1–194. 1910; 195–534. 1912. (P. 453.)
4. **Lindau, G.** Fungi Imperfecti. In Rab. Krypt.-Fl. 1^8: 1–852. 1904–07; 1^9: 1–984. 1907–10. (1^9: 146.)
5. **Mason, E. W.** Annotated account of fungi received at the Imperial Bureau of Mycology. List II. (Fascicle I.) 1–43. 1928. (Pp. 2–11.)
6. **Preuss, C. G. T.** Uebersicht untersuchter Pilze, besonders aus der Umgegend von Hoyerswerda. Linnaea **24**: 99–153. 1851. (P. 111.)
7. ——. In Sturm, Deuts. Fl. Abt. III. Heft 29–30. 1851. (**30**: *pl. 7.*)
8. **Saccardo, P. A.** Sylloge hyphomycetum. Syll. Fung. **4**: 1–808. 1886. (P. 484.)

CULTURAL STUDIES OF SOME SOIL FUNGI[1]

E. L. LeClerg

In a study of soil fungi of Colorado a survey was made of the fungus flora of our irrigated and non-irrigated soils. During this study it became evident that some criterium besides morphological characters was necessary for the accurate determination of the fungi isolated. It was thought that a knowledge of the cultural characters would be of assistance in the identification of soil forms. Most of the descriptions in the past have been based almost entirely upon morphological characters. Since these characters are extremely variable, no trustworthy separation is possible unless a more stable bases of classification can be established.

A review of the literature regarding the cultural characteristics of soil fungi as an aid to identification shows that data is scarce regarding many of the groups. Extensive studies of growth on various media is largely limited to specific groups or genera, such as Thom (**9**) and Woeltje (**11**) on the genus *Penicillium* and Thom and Church (**10**) and Blochwitz (**3**) on the *Aspergilli*. Abbott (**1**, **2**) found that fungi are not as specific in their reaction to carbohydrates as are bacteria and these substances can not be used in making specific determinations. Although it is doubtful if species can be separated on cultural characters alone, yet this information will be of assistance together with morphological characters in the identification of soil forms.

It is the purpose of this paper to make a study of the cultural characters of fungi which have been found to occur in Colorado soils.

The fungi cultivated during this work have been isolated from time to time over a period of two years. These do not, of course, constitute the entire fungus flora of Colorado soils, but are fairly

[1] The author takes pleasure in acknowledging his indebtedness to Dr. L. W. Durrell for advice regarding the manuscript and to Dr. J. C. Gilman, Iowa State College for help in identifying the species and for valuable criticism of the paper.

representative of the eastern part of the state, since they were obtained from about four hundred samples which were collected from various localities in this section.

The following species of soil fungi were isolated and constitute the basis for this work: *Rhizopus nigricans* Ehrenb.; *R. arrhizus* Fischer; *R. elegans* Eidam; *Mucor glomerella* (Bainier) Lendner; *M. lausannensis* Lendner; *Cunninghamella verticillata* Paine; *Trichoderma lignorum* (Tode) Harz; *Aspergillus minutus* Abbott; *A. flavus* Link; *A. terreus* Thom; *A. Wentii* Wehmer; *A. candidus* Group, Thom & Church; *A. orchraceous* Wilhelm; *Penicillium expansum* (Link) Thom; *P. stoloniferum; P. viridicatum* Westling; *P. commune* Thom; *P. purpurogenum* Stoll; *P. humicola* Oudemans; *P. citrinum* Thom; *P. chrysogenum* Thom; *P. digitatum* Sacc.; *Sporotrichum pruinosum* Gilman & Abbott; *Trichothecium roseum* Link; *Hormodendrum cladosporioides* (Fresen.) Sacc.

Methods and Media Used

Observations of cultural characters were made four to seven days after inoculation unless otherwise stated. The fungi were grown in Petri dishes and incubated at 22–25° C.

The media used are given below with the method of preparation of each:

Czapek. Cane sugar 30g; $NaNO_3$ 2g; K_2HPO_4 1g; $MgSO_4.7H_2O$ 0.5g; KCl 0.5g; $FeSO_4$ 0.01g; agar agar 15g; distilled water 1000cc.

Gelatin. A fifteen per cent gelatin medium was prepared by melting 150 grams of gelatin in a double boiler and enough water added to make one liter. This liquid was filtered and autoclaved.

Potato. To 250 grams of raw, ground potatoes, one-half liter of water was added and heated in a double boiler for one hour. The liquid was then filtered through cheese cloth and made up to a liter. Fifteen grams of agar agar were added, steamed, and autoclaved.

Peptone. Ten grams of Bacto Peptone and fifteen grams of agar agar were added to a liter of water, steamed, filtered, and autoclaved.

Starch. Twenty grams of starch were soaked in some cold

water for one-half hour and enough water then added to make a liter. To this 5 grams of agar agar were added, steamed, filtered, and autoclaved.

Malt Extract. A formula similar to that used by Thom and Church (10) was followed. The method used was to add 100 grams of Puritan Pure Malt Extract to 1000cc. of hot water. Fifteen grams of agar agar were added and the entire liquid steamed, filtered, and autoclaved.

Waksman's Medium. This medium was used to cultivate the fungi on the five sugars, maltose, dextrose, d-mannose, levulose, and inulin. The formula used is as follows: sugar 10g; peptone 5g; K_2HPO_4 1g; $MgSO_4.7H_2O$ 0.5g; agar agar15g; distilled water 1000cc.

In all this work chemically pure salts and sugars were used.

CULTURAL DATA OF SOME SOIL FUNGI

The work of Gilman and Abbott (**6**) was followed for the descriptions of the fungi reported in this paper, except in the case of the form which has not been previously isolated from the soil. The description of this species has been obtained from the papers of investigators who have worked on this form. These papers are cited with the name of the fungus.

Rhizopus nigricans Ehrenb.

Stolons creeping, recurving to the substratum in the form of arachnoid hyphae, which are strongly raised and distant from the substrate and implanted at each node by means of rhizoids. The internodes often attain a length of 1 to 3 cm. and the hyphae are more or less branched. Sporangiophores rarely single, united in groups of 3 to 5 or more, 0.5 to 4 mm. in height by 24 to 42 μ in diameter. Apophyses broad, cuneiform. Sporangia hemispheric 100 to 350 μ. Columellae broad, hemispheric, depressed, 70 μ in diameter by 90 μ in height (max. 250 by 320). Spores unequal, irregular, round or oval, angular, striate, 9 to 12 μ long by 7.5 to 8 μ in diameter, of a grey blue. Zygospores are round or oval, 160 to 220 μ in diameter. Exospore brown black, verrucose. Suspensors swollen, usually unequal. Azygospores present. No chlamydospores.

Cultural Data

Czapek.—Colonies white, broadly spreading, forming a very loose mat of hyphae and sporangiophores over the substratum. Growth scant. Sporangia production very poor. Reverse colorless.

Peptone.—Colonies same as on Czapek.

Malt.—Colonies same as on Czapek, except that the colonies are much more dense. Growth is rapid and good. Production of sporangia is very abundant.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on Czapek, except that sporangial production is a little more abundant.

Gelatin.—Colonies same as on Czapek, except that sporangial production is more profuse. Rapid liquefaction.

Maltose.—Colonies same as on Czapek, except that growth is rapid and abundant. Abundant sporangia are produced.

Mannose.—Colonies same as on malt agar.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on Czapek.

Dextrose.—Colonies same as on Czapek.

Rhizopus arrhizus Fischer

Differs from *R. nigricans* by being less exuberant. The felt is clearer and it does not extend so far into the substratum. Stolons are little developed and do not form nodes regularly. Rhizoids pale, develop at the nodes and carry sporangia, or are sometimes formed indeterminately. Sporangiophores often prostrate, rarely single, forming umbels or corymbs on their stolons. They measure 0.5 to 2 mm. in length. All the branches end in sporangia, of greater or less size. Sporangia spherical 120 to 250 μ in diameter. Columellae spherical, flattened on the apophyses, 40 to 75 μ high by 60 to 100 μ in width, membrane brown, smooth. Spores round or oval, or presenting obtuse angles, greyish brown; walls striated longitudinally, 4.8 to 7 μ by 4.8 to 5.6 μ.

Cultural Data

Czapek.—Colonies white, flat, spreading, only slightly elevated. Production of sporangia very poor. Growth very scant. Reverse colorless.

Peptone.—Colonies same as on Czapek, except that more abundant sporangia are produced, which gives the colonies a black appearance. Growth is rapid.

Malt.—Colonies same as on peptone, except that production of sporangia is even more abundant.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on Czapek, except that sporangial production is better.

Gelatin.—Colonies same as on Czapek, except that hyphae are longer and more broadly spreading. Sporangial production is much more abundant.

Maltose.—Colonies same as on peptone. Hyphae 3 to 5 mm. high.

Mannose.—Growth is more dense than on peptone and sporangial production is more abundant, otherwise similar to that on peptone.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on mannose.

Dextrose.—Colonies same as on mannose.

Rhizopus elegans Eidam (7, 8)

Sporangiophores rarely single, more often united, erect, bearing branches up to 1 to 2 mm. in length, membrane smooth, brownish. Sporangia spherical, small, the terminal sporangia 50 to 70 μ in diameter, the lateral only 33 μ in diameter. They are brown, elegantly ciliated or echinulate. Columellae spherical, smooth, clear brown. Spores spherical, 5 to 7 μ, smooth, clear brown. Zygospores unknown.

This fungus has never been reported from soils before. It was found quite abundantly in many soils in Colorado.

CULTURAL DATA

Czapek.—Colonies white, floccose, flat, and only slightly elevated, broadly spreading. Production of sporangia poor. Growth slow and very scant. Reverse colorless.

Peptone.—Colonies same as on Czapek, except that sporangial production is abundant and aërial hyphae are 2 to 5 mm. in height. Growth rapid.

Malt.—Colonies same as on peptone, except that sporangial

production is so abundant that the colonies become very black in color.

Starch.—Colonies same as on Czapek, except that hyphae are 3 to 5 mm. in height.

Potato.—Colonies same as on peptone, except that colonies are more elevated (1 to 1.5 cm.).

Gelatin.—Colonies same as on starch, except that sporangial production is much more abundant. Slight liquefaction.

Maltose.—Colonies same as on peptone.

Mannose.—Colonies same as on peptone.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on peptone.

Dextrose.—Colonies same as on peptone.

Mucor glomerella (Bainier) Lendner

Sporangiophores erect, very branched. Each erect branch terminated by a very large sporangium, below which occur a whorl of 3 to 8 secondary filaments, each terminated by a sporangium. These 3 to 8 filaments give rise in turn to a whorl of 3 to 5 sporangiferous filaments. The aërial mycelial filaments usually end in branches carrying nearly sessile sporangioles. Sporangia spherical, about 70 μ in diameter, hyaline, becoming sienna color when old. Wall roughened by crystals of calcium oxalate, diffluent leaving a colarette. Columellae variable in shape, hemispheric, cylindro-conic, ovoid, sometimes restricted, inserted at the rather suddenly expanded end of the sporangiophore. Spores round and smooth 2 to 5 μ in diameter. Aërial chlamydospores round, with thick wall, yellow and spiny. Content oleaginous. Mycelial chlamydospores seemingly submerged but very numerous. Zygospores unknown.

Cultural Data

Czapek.—Colonies grayish-white, very broadly spreading, densely floccose, aërial hyphae 8 to 10 mm. in height. Production of sporangia good. Oil globules very abundant. Growth very rapid. Reverse colorless.

Peptone.—Colonies same as on Czapek, except that aërial hyphae are only 5 to 7 mm. in height, and growth is much suppressed and poor.

Malt.—Colonies same as on Czapek, except that aërial hyphae are only about 6 to 8 mm. in height.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on Czapek.

Gelatin.—Colonies same as on Czapek, except that mycelium is more compact and sporangial production is very poor and often inhibited. No liquefaction.

Maltose.—Colonies same as on Czapek.

Mannose.—Colonies same as on Czapek.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on Czapek.

Dextrose.—Colonies same as on Czapek, except that mycelium is not as densely compact.

Mucor lausannensis Lendner

Sporangiophores erect, little branched, bearing laterally one or two groups of branches. These sporangiophores form a fine compact turf, yellowish, 0.5 to 1 cm. high (10 to 14 μ in diameter). Sporangia 40 to 54 μ in diameter, often flattened at the base. The wall is not diffluent; but fragile as in *M. racemosus*, leaving an irregular basal collarette. Columellae oval or spherical, 30 to 40 μ in diameter by 50 μ long. Spores oval, of very different sizes, the smallest 4 by 2 μ, the largest 12 μ long by 6 μ wide. The average size is 8 by 6 μ. They are hyaline, then pale, slowly turning yellowish in mass. Chlamydospores, rather rare, may be formed on either the mycelium or the sporangiophore. They measure on the average 15 by 14 μ, are smooth and granular in content. Zygospores not known.

CULTURAL DATA

Czapek.—Colonies broadly spreading, loosely floccose, white to gray, consisting of network of sporangiophores and mycelium 5 to 8 mm. in height. Mycelium filled with oil globules of varying sizes. Sporangial production very abundant. Growth rapid. Reverse colorless.

Peptone.—Colonies same as on Czapek, except that they are not as broadly spreading, mycelium and sporangiophores are only 2 to 3 mm. in height, and growth is poor and suppressed.

Malt.—Colonies same as on Czapek.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on Czapek.

Gelatin.—Colonies same as on Czapek. No liquefaction.

Maltose.—Colonies same as on Czapek, except that they are more elevated, being 8 to 10 mm. in height, and growth is not as rapid.

Mannose.—Colonies same as on Czapek, except that growth is very slow.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on Czapek, except that growth is very slow.

Dextrose.—Colonies same as on Czapek, except that growth is very slow.

Cunninghamella verticillata Paine

Conidiophores very long, 2 cm. or more by 12 to 14 μ in thickness. Numerous lateral branches are borne at various places along the conidiophores just below the terminal vesicle, forming a number of whorls of two to six lateral branches, each terminating in a vesicle. The conidiophore is more or less swollen at each point of attachment of the lateral branches; lateral branches not exceeding 30 μ in length, their vesicles pyriform or oval, not over 16 μ in diameter. The terminal vesicle globose to oval, about 50 μ in diameter. Spores borne on the terminal vesicle ellipsoid, pointed at the attached end, 10 μ by 13 to 15 μ; spores borne on the lateral vesicles oval, bluntly pointed at the attached end, 8 to 12 μ in diameter; all spores are finely echinulate, echinulations 1.5 to 3 μ in length.

Cultural Data

Czapek.—Colonies broadly spreading, effuse, grayish white, aërial hyphae very much elevated (8 to 10 mm.). Growth rapid, conidial production good. Reverse colorless.

Peptone.—Colonies same as on Czapek, except that aërial hyphae are only slightly elevated, growth is suppressed and slow.

Malt.—Colonies same as on Czapek.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on peptone.

Gelatin.—Colonies same as on Czapek. No liquefaction.

Maltose.—Colonies same as on Czapek.

Mannose.—Colonies same as on Czapek.

Inulin.—Colonies same as on Czapek, except that spreading is much slower.

Levulose.—Colonies same as on Czapek.

Dextrose.—Colonies same as on Czapek.

Trichoderma lignorum (Tode) Harz

Conidiophores arise as branches of aërial mycelium, septate, up to 70 μ in height by 3 μ in diameter, di- or tri-chotomously branched, occasionally forming whorls. Conidial heads up to 10 μ in diameter; conidia globose to ovoid, smooth, 3.8 to 3.2 μ in diameter.

CULTURAL DATA

Maltose.—Colonies round, broadly spreading as sterile mycelium, hyalescent, markedly depressed in the center, loosely floccose, prostrate. Fruiting areas appear as tufts, white at first later becoming yellow to green and more abundant near margin of the colony. Growth very rapid. Reverse cream colored.

Mannose.—Colonies same as on maltose, except that they are a darker green, zonate and reverse is white to light green.

Inulin.—Colonies same as on maltose, except that growth is very slow and scarce and slowly spreading. Reverse colorless.

Levulose.—Colonies same as on maltose, except that mycelium is more coarse and zonations are present.

Dextrose.—Colonies same as on maltose, except that mycelium is denser and extends about 3 mm. above the surface. Colonies are zonate.

Aspergillus fumigatus Fres.

Conidiophores short, usually densely crowded, up to 300 μ (occasionally 500 μ), by 2 to 8 μ in diameter, arising directly from submerged hyphae or as branches from aërial hyphae, septate or non-septate, gradually enlarged, upward, with apical flash-shaped vesicles up to 20 to 30 μ in diameter, fertile usually only on the upper half, bearing sterigmata in one series, usually 6 to 8 μ by 2 to 3 μ, crowded, closely packed, with axis roughly parallel to axis of the stalk; chains of conidia form solid columns up to 400 by 50 μ; conidia dark green in mass, globose, 2 to 3 μ, mostly 2.5 to 3 μ.

CULTURAL DATA

Czapek.—Colonies loosely floccose, spreading, white at first soon becoming light green then dark green with white margin. Growth slow. Spore production good. Reverse colorless to light yellow.

Peptone.—Colonies same as on Czapek, except that spore production is poor.

Malt.—Reverse yellow to light brown, otherwise same as on Czapek.

Starch.—Reverse colorless to light green, otherwise same as on Czapek.

Potato.—Colonies same as on starch.

Gelatin.—Reverse dark green and spore production good, otherwise same as on starch. No liquefaction.

Maltose.—Colonies same as on starch, except that reverse is cream to yellowish green; slightly zonate.

Mannose.—Colonies same as on maltose.

Inulin.—Colonies same as on maltose.

Levulose.—Colonies same as on maltose, except that zonations are absent.

Dextrose.—Colonies same as on maltose.

Aspergillus minutus Abbott

Conidiophores septate, arising as short side branches of aërial mycelium, 30 to 60 μ long by 3 μ in diameter, rarely attaining a height of 125 μ; also arise directly from substratum, up to 250 μ. Heads round and radiate in young cultures, later tending toward calyptriform; vesicles small, 8 to 18 μ in diameter, globose; sterigmata in two series, primary 4.8 to 6.5 μ by 3.5 to 3.8 μ, secondary 4.8 by 3.2 μ. Conidia globose, verrucose, light greenish brown in mass, 3.2 to 4.5 μ in diameter, mode 3.5 μ.

Cultural Data

Czapek.—Colonies irregular, cottony, white and later becoming dark gray with narrow white margin, slowly spreading, slightly elevated. Growth slow. Conidial production good. Reverse light yellow to orange.

Peptone.—Colonies round, small, flat, white but soon becoming gray then dark brown to black with white margin at time of spore production. Growth slow. Spore production good. Reverse colorless to grayish green.

Malt.—Colonies large, round. Growth rapid. Reverse brown and wrinkled, otherwise same as on Czapek.

Starch.—Colonies same as on peptone, except that reverse is dark.

Potato.—Colonies same as on starch. Abundance of flocculent mycelium present around edges.

Gelatin.—Colonies same as on potato, except that reverse is colorless. Liquefaction slow.

Maltose.—Reverse olive green to light brown, otherwise same as on malt.

Mannose.—Reverse yellow to dark brown, otherwise same as on malt.

Inulin.—Colonies same as on Czapek, except that spore production is very abundant and reverse is light green to dark gray, otherwise same as on Czapek.

Levulose.—Colonies same as on inulin.

Dextrose.—Reverse yellow to delicate green, otherwise same as on mannose.

Aspergillus flavus Link

Conidiophores arise separately from the substratum, 400 to 700 or 1000 μ long by 5 to 15 μ in diameter, broadening upward, walls so pitted as to appear rough or spiny, occasionally granular, gradually enlarging upward to form a vesicle 10 to 30 or 40 μ in diameter. Small heads with small dome-like vesicles and single series of a few sterigmata up to 10 to 15 μ by 3 to 5 μ; larger heads partly with simple sterigmata, partly with branched or double series or with both in the same head; primary sterigmata 7 to 10 μ by 3 to 4 μ; secondary 7 to 10 μ by 2.5 to 3.5 μ; conidia pyriform to almost globose, colorless to yellowish green, sometimes almost smooth, usually rough, varying from 2 by 3 μ, 3 by 4 μ, 4 by 5 μ or 5 by 6 μ in diameter or even larger.

CULTURAL DATA

Czapek.—Colonies large, broadly spreading, round, loosely floccose, moderate elevation, white and soon becoming yellow with white margin. Growth rapid. Spore production poor. Sclerotia quite abundant in old cultures. Reverse yellow and wrinkled.

Peptone.—Reverse colorless, otherwise same as on Czapek.

Malt.—Colonies exceptionally large, consisting mostly of cottony mycelium except in center where conidiophores are produced, elevation 3 to 4 mm. Growth very rapid and abundant. Conidial production good. Sclerotia produced very abundantly in old cultures.

Starch.—Colonies same as on peptone.

Potato.—Colonies same as on Czapek.

Gelatin.—Reverse dark yellow to almost brown. No sclerotia formed, otherwise same as on Czapek.

Maltose.—Colonies same as on malt.

Mannose.—Colonies same as on malt.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on Czapek.

Dextrose.—Colonies same as on malt.

Aspergillus terreus Thom

Conidiophores to 150 or even 250 μ long by 5 to 8 μ, more or less flexuous, with walls smooth, septate or non-septate, with apex enlarged to form a vesicle commonly 12 to 18 μ, occasionally up to 25 μ in diameter, bearing sterigmata usually in two series upon its dome-like upper surface; primary sterigmata 7 to 9 μ by 2 to 2.5 μ; secondary 5 to 7 μ by 2 to 2.5 μ; closely packed. Heads becoming solid columnar masses up to 500 μ long by 50 μ in diameter; conidia elliptical to globose, 2.2 to 2.5 μ or even 3 μ in diameter, smooth, in long, parallel, adherent chains.

Cultural Data

Czapek.—Colonies not very large, velvety, round, slowly spreading, slightly elevated, white at first and slowly changing to light cinnamon then to brown. Growth rapid. Spore production abundant. Reverse dark brown.

Peptone.—Colonies small. Oil globules abundant in mycelium. Spore production only fair. Reverse colorless to light yellow, otherwise same as on Czapek.

Malt.—Colonies very large, rapidly spreading, moderate elevation. Growth very rapid, spore production very poor in young cultures. Oil globules very abundant in mycelium. Reverse light yellow and wrinkled, otherwise same as on Czapek.

Starch.—Colonies scarcely rising above substratum. Growth limited to a few aërial hyphae. Spore production very poor and formed in more or less definite rings. Medium colored yellow. Reverse yellow, otherwise same as on Czapek.

Potato.—Colonies ochraceous and zonate, otherwise same as on Czapek.

Gelatin.—Colonies same as on peptone. Slight liquefaction.

Maltose.—Colonies same as on Czapek, except that reverse is bright yellow.

Mannose.—Colonies same as on maltose.

Inulin.—Growth poor, otherwise same as on peptone.

Levulose.—Colonies same as on maltose.

Dextrose.—Colonies same as on maltose.

Aspergillus Wentii Wehmer

Conidiophores 2 or 3 up to 5 mm. long, 10 to 12 or 25 μ in diameter, 1- to 2-septate, walls thick, smooth, enlarged at tips to vesicles varying up to 80 μ in diameter; heads large, yellow to brown, radiate; sterigmata usually in two series, primary varying greatly, 6 to 8 μ, occasionally to 15 μ by 3 to 5 μ; secondary 6 to 8 μ by 3 μ; conidia pyriform to globose, usually 4 to 5 μ, less commonly up to 5 or 6 μ; walls often pitted or furrowed, frequently appearing smooth or nearly so.

CULTURAL DATA

Czapek.—Colonies irregular, slightly spreading, small, white and soon becoming medal bronze with broad white margin. Growth slow. Conidia abundantly produced. Reverse yellow to brown.

Peptone.—Colonies same as on Czapek.

Malt.—Colonies round, rapidly spreading, white but soon becoming grayish yellow and the conidial heads are covered with mycelium. Growth rapid. Reverse orange to brown and wrinkled, otherwise same as on Czapek.

Starch.—Reverse colorless, otherwise same as on Czapek.

Potato.—Colonies same as on malt.

Gelatin.—Colonies same as on Czapek.

Maltose.—Conidial production very abundant, otherwise same as on Czapek.

Mannose.—Colonies same as on maltose.

Inulin.—Colonies same as on maltose.

Levulose.—Colonies same as on maltose.

Dextrose.—Colonies same as on maltose.

Aspergillus candidus Group, Thom & Church

Conidiophores vary with the strain, less than 500 μ long up to 1000 μ or longer by 5 or 10 or 20 μ in diameter, walls thick, smooth; heads white, globose, radiate, varying from large globose masses

200 to 300 μ in diameter, to small heads less than 100 μ in diameter; vesicles typically globose, up to 50 μ in very large heads, fertile over the whole surface; sterigmata typically in two series, primary 5 to 10 μ or even 15 to 20 μ long, secondary 5 to 8 μ by 2 to 2.5 or 3 μ; conidia colorless, globose, smooth, 2.5 to 3.5 or 4 μ.

Cultural Data

Czapek.—Colonies small, slowly spreading, round, white and soon turning to yellowish cream; surface growth consisting mostly of stalks and heads. Growth slow. Conidial production abundant. Reverse dark brown.

Peptone.—Colonies same as on Czapek.

Malt.—Colonies large, irregular, zonate, with prominent white margin. Growth rapid. Reverse orange to light brown and somewhat wrinkled, otherwise same as on Czapek.

Starch.—Reverse colorless, otherwise same as on Czapek.

Potato.—Colonies same as on Czapek.

Gelatin.—Colonies same as on Czapek. Liquefaction.

Maltose.—Reverse wrinkled, light brown and with concentric rings, otherwise same as on Czapek.

Mannose.—Colonies same as on maltose.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on maltose.

Dextrose.—Reverse not wrinkled and concentric rings lacking, otherwise same as on maltose.

Aspergillus niger Group, Thom & Church

Conidiophores mostly arise directly from the substratum, smooth, septate or non-septate, varying greatly in length and diameter, 200 to 400 μ by 7 to 10 μ or several millimeters long and 20 μ in diameter; conidial heads varying from small, almost columnar masses of a few conidial chains to the more common globose or radiate heads, up to 300, 500 or 1000 μ long; vesicles globose, commonly 20 to 50 μ up to 100 μ in diameter; sterigmata typically in two series, thickly covering the vesicle, primary varying greatly in length, secondary 6 to 10 μ by 2 to 3 μ; conidia globose, at first smooth, but later spinulose with coloring substance, mostly 2.5 to 4 μ, less frequently 5 μ.

CULTURAL DATA

Czapek.—Colonies large, slightly elevated, broadly spreading, white at first and soon becoming black with broad white margin; consists mostly of stalks and heads. Growth very rapid. Spore production very abundant. Reverse colorless.

Peptone.—Colonies of medium size, flat, of very loose growth, white then black with broad white margin. Growth slow and scant. Spore production poor. Reverse colorless.

Malt.—Reverse wrinkled and growth more profuse, otherwise colonies are same as on Czapek.

Starch.—Colonies similar to those on peptone.

Potato.—Colonies same as on Czapek.

Gelatin.—Colonies similar to those on peptone. No liquefaction.

Maltose.—Reverse colorless to yellow and wrinkled, otherwise same as on Czapek.

Mannose.—Reverse smooth, otherwise same as on maltose.

Inulin.—Colonies same as on mannose.

Levulose.—Colonies same as on maltose.

Dextrose.—Colonies same as on mannose.

Aspergillus ochraceous Wilhelm

Conidiophores variable in length, commonly several millimeters, rough or pitted, bearing large, radiate conidial heads. Vesicles globose 60 to 75 μ in diameter; sterigmata in two series, primary commonly 15 to 30 μ long, although sometimes longer, secondary 7 to 10 μ by 1.5 to 2 μ; conidia globose to elliptical, smooth or delicately spinulose, yellow, 3.5 by 5 μ or 3.5 by 4 or 4.5 μ.

CULTURAL DATA

Czapek.—Colonies large, round, slightly elevated, white at first and soon becoming ochraceous, spreading with a narrow white margin. Growth rapid. Conidial production abundant. Reverse colorless.

Peptone.—Colonies very small. Growth slow and scant. Spore production fair, otherwise same as on Czapek.

Malt.—Colonies with considerable elevation and spreading with a broad white margin. Reverse colorless to light yellow and wrinkled, otherwise same as on Czapek.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on Czapek.

Gelatin.—Colonies same as on peptone. Rapid liquefaction.

Maltose.—Colonies same as on Czapek.

Mannose.—Colonies same as on Czapek.

Inulin.—Colonies same as on peptone.

Levulose.—Colonies same as on Czapek.

Dextrose.—Colonies same as on Czapek.

Penicillium expansum (Link) Thom

Conidiophores either very short lateral branches of aërial hyphae or very long, 1 mm. or more, arising singly or sometimes grouped to form coremia. Conidial fructifications typically in three stages, 130 to 200 μ by 50 to 60 μ, consisting of one to three primary branches bearing verticils of metulae supporting crowded whorls of phialides; phialides 8 to 10 μ by 2 to 3 μ. Conidia elliptical to globose, 2 to 3.3 μ or 3 to 3.4 μ, green.

Cultural Data

Czapek.—Colonies densely floccose, large, spreading, slightly elevated, white at first soon becoming green or grayish green with margin of sterile, white mycelia. Growth rapid. Spore production abundant. Reverse orange to brown.

Peptone.—Colonies very small, flat, white and very slow to become grayish green. Growth very slow. Spore production very abundant. Reverse colorless.

Malt.—Colonies same as on Czapek, except that reverse is bright orange in color and wrinkled.

Starch.—Colonies same as on peptone.

Potato.—Colonies same as on Czapek, except that reverse is colorless.

Gelatin.—Colonies same as on peptone, except that reverse is colorless. No liquefaction in young cultures.

Maltose.—Colonies same as on Czapek, except that reverse is brilliant reddish orange.

Mannose.—Colonies same as on Czapek, except that reverse is light brownish yellow.

Inulin.—Colonies same as on Czapek, except that fruiting areas are in small round groups and reverse is dark reddish orange.

Levulose.—Colonies same as on Czapek, except that reverse is white to dark yellow.

Dextrose.—Colonies slightly elevated, granular in appearance, large, white and rapidly becoming light blue, with margin of sterile white mycelium. Growth rapid. Spore production good. Reverse reddish yellow.

Penicillium stoloniferum Thom

Conidiophores arise as short branches of aërial hyphae up to 100 μ or arising separately 300 μ or more in length. Conidial fructifications 40 to 80 μ or rarely up to 170 μ long; usually in three stages, phialides 10 by 3 μ. Conidia slightly elliptical or globose, 2.8 to 3.4 μ, smooth, yellowish green in mass.

CULTURAL DATA

Czapek.—Colonies densely floccose, broadly spreading, slightly elevated, white and soon becoming dark green with white margin. Growth rapid. Spore production abundant. Reverse colorless.

Peptone.—Colonies very small, flat, floccose, slowly spreading. Growth slow. Spore production good. Reverse green or yellowish green, otherwise characters are same as on Czapek.

Malt.—Colonies same as on Czapek, except that reverse is orange to brown.

Starch.—Colonies same as on peptone, except that reverse is colorless.

Gelatin.—Colonies same as on Czapek, except that reverse is colorless to light green. Rapid liquefaction.

Potato.—Colonies same as on starch.

Maltose.—Colonies same as on Czapek, except that reverse is colorless at first and later becomes a faint green.

Mannose.—Colonies same as on Czapek, except that rather indefinite concentric rings are present and reverse becomes pale green with age.

Inulin.—Colonies same as on Czapek, except that growth is slow and reverse is colorless to green.

Levulose.—Colonies same as on mannose.

Dextrose.—Colonies same as on inulin.

Penicillium viridicatum Westling

Conidiophores usually arise from the substratum, but also from aërial mycelium, 75 to 250 μ by 4 to 6 μ. Heads vary from

loose, almost radiate masses of chains to loose columns. Fructifications in three stages, usually with one primary branch arising laterally, a second primary branch being the prolongation of the conidiophore through the center of the head. Primary branches variable in length, 17 to 30 μ by 3 to 4 μ; metulae 13 to 20 μ by 3.5 to 4 μ; phialides 7.5 to 10.5 μ by 2.5 to 3 μ. Some heads have only metulae and phialides. Conidia smooth, globose, light green, 3 to 4 μ in diameter.

Cultural Data

Czapek.—Colonies velvety, round, moderately elevated, restricted in growth; white at first soon becoming leaf green with narrow opaque margin; surface has powdery appearance. Growth slow. Spore production good. Reverse brown.

Peptone.—Colonies same as on Czapek, except that they become grayish green in color.

Malt.—Colonies same as on peptone, except that growth is rapid and spore production poor. Reverse yellow to brown.

Starch.—Colonies small and scattered, otherwise same as on peptone.

Potato.—Colonies same as on peptone.

Gelatin.—Colonies same as on peptone. Rapid liquefaction.

Maltose.—Colonies small, growth rapid and reverse light yellow, otherwise same as on Czapek.

Mannose.—Colonies same as on maltose.

Inulin.—Colonies very small, otherwise same as on maltose.

Levulose.—Colonies same as on maltose, except that reverse is brown and they are covered with floccose mycelia.

Dextrose.—Colonies same as on maltose, except that reverse is dark yellow.

Penicillium commune Thom

Conidiophores commonly 300 μ or less in length, sometimes up to 700 μ. Conidial fructifications commonly 100 to 200 μ in length, in three stages, compact at the base and broadening above, variously branched, with branches appressed; phialides 8 to 9 μ by 3 μ. Conidia elliptical to globose, 3 to 4 μ, smooth, green.

Cultural Data

Czapek.—Colonies spreading, white at first then dull green with broad white margin, moderate elevation. Growth rapid. Spore production good. Reverse yellow to orange.

Peptone.—Colonies very small. Growth slow and scant. Reverse colorless, otherwise same as on Czapek.

Malt.—Colonies same as on Czapek, except that reverse is very dark orange in color and wrinkled.

Potato.—Colonies same as on Czapek, except that reverse is colorless.

Gelatin.—Colonies same as on peptone. No liquefaction in young cultures.

Maltose.—Colonies same as on Czapek, except that reverse is a brilliant reddish orange.

Mannose.—Colonies same as on Czapek, except that reverse is bright yellow.

Inulin.—Colonies same as on peptone, except that reverse is reddish orange.

Levulose.—Colonies same as on Czapek.

Dextrose.—Colonies same as on Czapek, except that reverse is reddish orange.

Penicillium purpurogenum Stoll

Conidiophores arise from aërial mycelium, up to 100 or 300 μ long. Conidial fructifications consist of long, divergent chains, up to 100 μ long, in two stages; metulae 10 to 16 μ by 2 to 2.5 μ; phialides 11 to 12 μ by 2.5 μ. Conidia elliptical, 3.4 to 3.8 μ or 2 to 2.5 μ, smooth, pale green.

CULTURAL DATA

Czapek.—Colonies closely floccose, to velutinous, white at first and soon becoming yellow to pink; narrow, white margin present. Growth rapid. Spore production good. Reverse dark yellow to red.

Malt.—Growth so rapid and spore production so abundant that a solid mass of spores is formed over the surface, otherwise same as on Czapek.

Potato.—Colonies same as on Czapek.

Gelatin.—Colonies very small and scattered. Growth slow and scant. Spore production fair. Reverse colorless, otherwise same as on Czapek. Liquefaction very slow.

Maltose.—Colonies same as on Czapek.

Mannose.—Colonies same as on Czapek.

Inulin.—Colonies same as on gelatin.

Levulose.—Colonies same as on Czapek. Medium colored red.

Dextrose.—Colonies same as on Czapek.

Penicillium humicola Oudem.

Conidiophores arise both directly from the substratum and from aërial hyphae up to 135 μ long. Heads loosely penicillate and straggling, breaking up easily; fructifications in two stages, a single verticil of oblong metulae bearing the elongate and slightly pointed phialiades; metulae 9.5 to 11.5 μ by 2 to 3 μ; phialides 6.5 to 8 μ by 1 to 2 μ; some heads have phialides only. Conidia ovoid to globose, smooth, olive green, 2 to 3 μ by 1.5 to 2 μ.

Cultural Data

Czapek.—Colonies round, cottony, moderately elevated, white and soon becoming grayish green with broad white margin. Growth rapid. Spore production good. Reverse colorless to yellow.

Peptone.—Growth slow and scanty. Reverse colorless, otherwise same as on Czapek.

Malt.—Colonies same as on Czapek, except that reverse is deep orange and wrinkled.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on Czapek, except that reverse is colorless to light green.

Gelatin.—Colonies same as on potato. Liquefaction.

Maltose.—Colonies same as on Czapek. Zonate.

Mannose.—Colonies same as on potato. Concentric rings present on reverse.

Inulin.—Colonies zonate, otherwise same as on potato.

Levulose.—Colonies same as on inulin.

Dextrose.—Colonies same as on maltose.

Penicillium citrinum Thom

Conidiophores arise separately from submerged hyphae or from mycelium on the surface, usually up to 150 μ in length (rarely 300 μ). Conidial fructifications up to 150 μ in length (rarely 300 μ), in two stages; metulae 16 to 30 μ by 3 μ, enlarged at the apex to 5 μ each producing a compact verticil of phialides 6 to 7 μ by 2 to 3 μ. Conidial chains in columns, a separate column arising from each verticil of cells, so that the fructifications may appear double, triple, or even more complex. Conidia globose, 2.4 to 3 μ or 3.5 μ, green, slightly granular.

CULTURAL DATA

Czapek.—Colonies dense, velvety, spreading, moderate elevation, white soon becoming bluish green with white margin. Growth very rapid. Spore production abundant. Reverse yellow to brown and wrinkled on edges.

Peptone.—Colonies very small, only slightly elevated. Growth slow and poor. Reverse brown, otherwise same as on Czapek.

Malt.—Colonies same as on Czapek.

Starch.—Reverse colorless, otherwise same as on peptone.

Potato.—Growth rapid. Reverse colorless, otherwise same as on peptone.

Gelatin.—Reverse colorless and smooth. Medium colored, otherwise same as on Czapek. Rapid liquefaction.

Maltose.—Growth slow. Reverse white then bright lemon yellow, otherwise same as on Czapek.

Mannose.—Colonies same as on maltose.

Inulin.—Colonies same as on maltose.

Levulose.—Colonies same as on maltose.

Dextrose.—Colonies same as on maltose, except that reverse is white and growth is rapid.

Penicillium chrysogenum Thom

Conidiophores arise separately, up to 300 μ long; some as short branches of aërial hyphae. Conidial fructifications 100 to 200 μ long with one or two alternate, divergent branches; usually in two stages, but may also have three; phialides 8 by 2.5 μ. Conidia elliptical, becoming globose, 3 to 4 μ, pale green.

CULTURAL DATA

Czapek.—Colonies round, broadly spreading, moderately elevated, densely floccose, white at first and soon becoming grayish green with white margin. Growth rapid. Spore production good. Reverse yellow.

Peptone.—Colonies loosely floccose. Growth slow and poor. Spore production fair. Reverse colorless, otherwise same as on Czapek.

Malt.—Colonies same as on Czapek, except that reverse is dark yellow to orange and wrinkled.

Starch.—Colonies very small, scattered, flat, dense, otherwise same as on peptone.

Potato.—Colonies same as on malt.

Gelatin.—Colonies same as on peptone. Slow liquefaction.

Maltose.—Colonies same as on Czapek.

Mannose.—Colonies same as on Czapek.

Inulin.—Colonies have a tinge of blue and not as much green. Reverse white to yellow, otherwise same as on peptone.

Levulose.—Growth very rapid. Reverse yellow to light green, otherwise same as on Czapek.

Dextrose.—Colonies same as on peptone, except that reverse is light yellow.

Penicillium digitatum Saccardo

Conidiophores arise directly from the substratum 30 to 100 μ by 4 to 5 μ, usually very short. Conidial fructifications a few tangled conidial chains up to 160 μ in length, in two stages; phialides 13 to 16 μ by 3 to 4 μ. Conidia cylindrical to almost globose, 4 to 7 μ by 6 to 8 μ, often uneven in size and shape in the same chain.

Cultural Data

Czapek.—Colonies very dense, irregular, elevated, white at first and slowly becoming grayish olive. Growth rapid. Spore production slow and not abundant. Reverse brown to dark brown.

Peptone.—Growth not very rapid. Reverse white to yellow, otherwise same as on Czapek.

Malt.—Few if any spores produced in 4 to 6 day-old cultures. Reverse reddish orange, otherwise same as on Czapek.

Starch.—Colonies small and scattered. Reverse colorless, otherwise same as on peptone.

Potato.—Colonies same as on malt, except that reverse is brown and smooth.

Gelatin.—Colonies same as on peptone. Slow liquefaction.

Maltose.—Colonies delicate blue. Reverse white at first later becoming brown, otherwise same as on Czapek.

Mannose.—Colonies same as on Czapek, except that reverse is yellow and growth is slow.

Inulin.—Colonies same as on Czapek.

Levulose.—Reverse yellow to brown. Colonies zonate, otherwise same as on Czapek.

Dextrose.—Reverse yellow to green. Colonies zonate, otherwise same as on Czapek.

Sporotrichum pruinosum Gilman & Abbott

Aërial hyphae branched, hyaline, often roughened from which the conidiophores arise as branches; sterile hyphae often roped up to 10 μ thick. Conidiophores freely branched, oppositely or irregularly up to 25 μ long, bearing terminal conidia, oval or lemon-shaped, 9.5 to 13.5 μ by 6 to 10 μ; appearing grayish.

CULTURAL DATA

Czapek.—Hyphae creeping, very prostrate, white, slowly spreading. Growth very scant. Spore production poor. Reverse colorless.

Peptone.—Colonies same as on Czapek, except that growth is slower and they are denser. No spores are produced on this medium.

Malt.—Colonies same as on Czapek, except that they are densely floccose, slightly elevated and spore production sparse or lacking.

Starch.—Colonies same as on Czapek, except that growth is rapid.

Potato.—Colonies same as on starch.

Gelatin.—Colonies same as on Czapek. No liquefaction.

Maltose.—Colonies same as on malt.

Mannose.—Colonies same as on starch, except that spore production is very abundant.

Inulin.—Colonies same as on malt.

Levulose.—Colonies same as on mannose.

Dextrose.—Colonies same as on malt.

Trichothecium roseum Link (4, 5)

Conidiophores erect, simple, compact, hyaline, and continuous. Conidia oblong-obovoid, 2-celled, slightly constricted at the septum, rose colored and formed in heads at the end of the conidiophores, 16 to 20 μ in length by 8 to 14 μ in width.

According to Gilman and Abbott (6) *Cephalothecium roseum* Corda is considered the same as *Trichothecium roseum* Link. Their terminology is followed in this instance.

Cultural Data

Czapek.—Colonies somewhat spreading, white at first later turning pink, flat, round, floccose, consisting almost entirely of conidiophores. Growth suppressed. Spore production very abundant. Reverse colorless to pale pink.

Peptone.—Colonies same as on Czapek.

Malt.—Colonies same as on Czapek, except that growth is more rapid and spore production much more abundant.

Starch.—Colonies same as on Czapek.

Potato.—Colonies same as on Czapek.

Gelatin.—Colonies same as on malt. Liquefaction.

Maltose.—Colonies same as on Czapek.

Mannose.—Colonies same as on Czapek, except that they are small and turn pink very much sooner.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on Czapek.

Dextrose.—Colonies same as on Czapek.

Hormodendrum cladosporioides (Fresenius) Saccardo

Conidiophores erect, branched, 100 to 200 μ long, olivaceous, toward the apex gradually alternate, ultimate branching copiously dividing with predominant tendency to dichotomy, septate, articulate above; conidia cylindrical to broadly oval, olivaceous, smooth, 3 to 6 μ by 2.5 to 3.6 μ, continuous or inferior ones rarely septate.

Cultural Data

Czapek.—Colonies orbicular, dense, flat, spreading, with narrow margin, at first grayish, becoming olivaceous green. Growth rapid. Spore production very abundant. Reverse black.

Peptone.—Colonies same as on Czapek, except that color changes to grayish green, growth is slower and reverse is greenish black.

Malt.—Colonies same as on peptone, except that center is elevated, growth is rapid and reverse is black and wrinkled.

Starch.—Colonies same as on malt, except that reverse is not wrinkled.

Potato.—Colonies same as on starch.

Gelatin.—Colonies same as on starch. Rapid liquefaction.

Maltose.—Colonies same as on Czapek.

Mannose.—Colonies same as on Czapek.

Inulin.—Colonies same as on Czapek.

Levulose.—Colonies same as on Czapek, except that reverse is darker and has concentric rings. Growth is very slow.

Dextrose.—Colonies same as on Czapek.

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LITERATURE CITED

1. **Abbott, E. V.** Notes on the fungus flora of Iowa soils. Proc. Iowa Acad. Sci. **33:** 115–117. 1924.
2. ——. Taxonomic studies on soil fungi. Iowa State Coll. Jour. Sci. **1:** 15–36. 1926.
3. **Blochwitz, A.** Verleichende Physiologie der Gattung *Aspergillus.* Centralbl. Bakt. II. **39:** 497–502. 1913.
4. **Engler, A. & Prantl, K.** Die natürlichen Pflanzenfamilien. **1⁴:** 570. 1900.
5. **Eustace, H. J.** A destructive apple rot following scab. N. Y. Agr. Exp. Sta. (Geneva) Bull. 227: 367–389. 1902.
6. **Gilman, J. C. & Abbott, E. V.** A summary of the soil fungi. Iowa State Coll. Jour. Sci. **1:** 225–343. 1927.
7. **Hanzawa, J. von.** Studien über einige *Rhizopus*-Arten. Mycol. Centralbl. **5:** 230–246. 1914.
8. **Lendner, A.** Les Mucorinées de la Suisse, 180. Berne. 1908.
9. **Thom, C.** Cultural studies of species of *Penicillium.* U. S. Dept. Agr. Animal Ind. Bull. 118: 1–109. 1910.
10. —— **& Church, M. B.** The Aspergilli. 272. 1926.
11. **Woeltje, Wm.** Unterscheidung einer *Penicillium* Spezies nach physiologischer Merkmalen. Centralbl. Bakt. II. **48:** 97–130. 1918.

NOTES AND BRIEF ARTICLES

In order to meet the increase in demand for space in MYCOLOGIA the question of raising the price to five dollars ($5.00) per year and the size proportionately is being seriously considered. Since MYCOLOGIA is self-supporting and the Editor would like to keep it so, expressions of opinion from subscribers as to the advisability of this move would be appreciated. It should also be mentioned that every additional subscription means a potential increase in the size of the publication.

Mr. Carlos E. Chardon, Commissioner of Agriculture and Labor of Porto Rico, and Mr. Rafael A. Toro, Plant Pathologist of the Department of Horticulture of Colombia, spent some time at the Garden during the month of May working over their collections of South American Fungi, preparatory to the publication of a check list of the fungi of Colombia.

Professor H. H. Whetzel of Cornell University sailed during the spring for Europe where he will spend several months studying European collections of the Sclerotinieae. He has already contributed much to our knowledge of the life histories of the various species of this tribe and expects within the next few years to complete a monograph of this section of the cup-fungi.

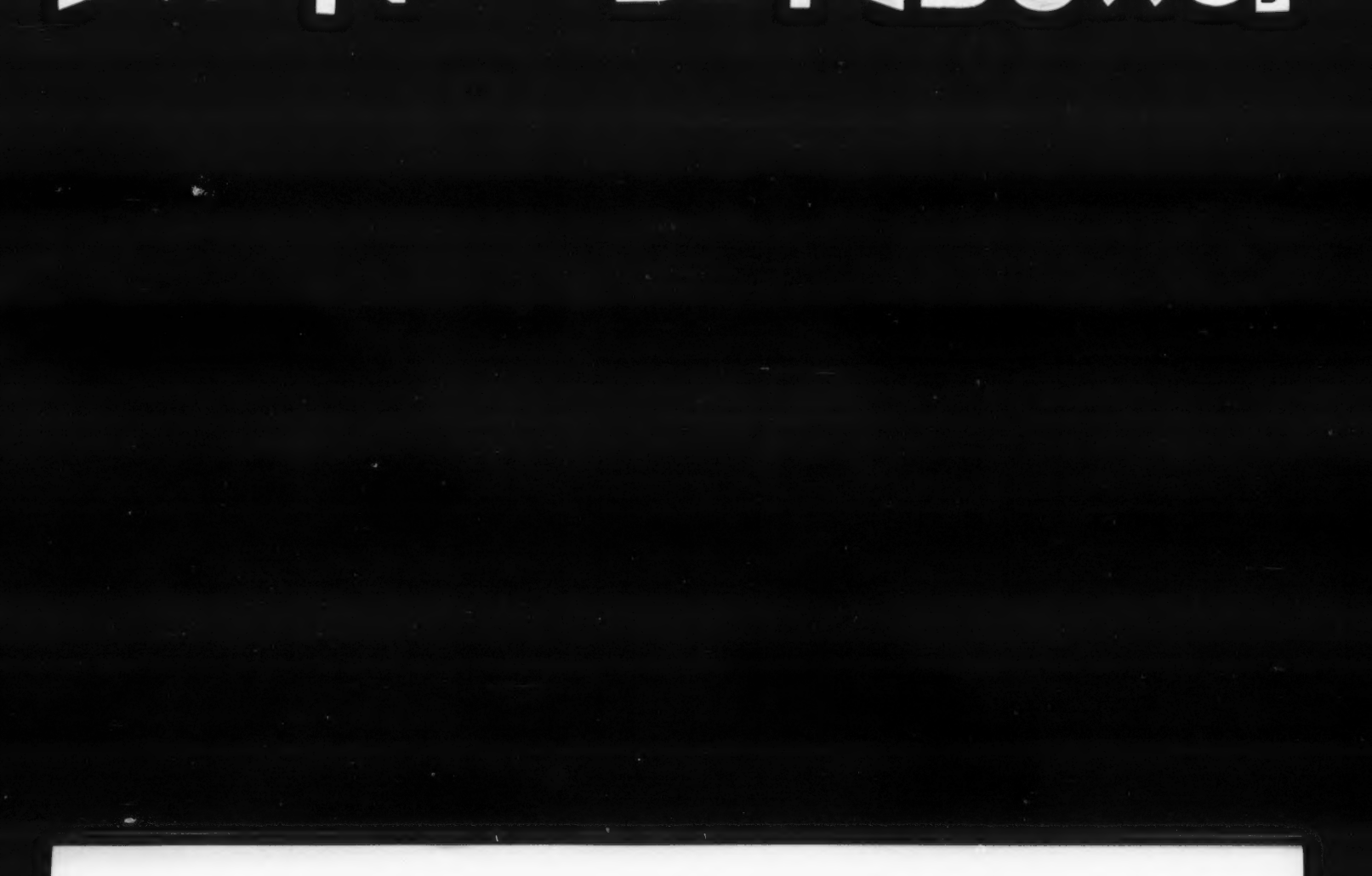
Mr. Robert Hagelstein of Mineola, Long Island, has recently been appointed Honorary Curator of the Myxomycetes of The New York Botanical Garden. Mr. Hagelstein has devoted much time to the study of the diatoms and myxomycetes and has one of the largest private collections of the latter to be found in the East. He will spend some time at the Museum Building arranging and studying the Garden collection of slime-moulds.

In MYCOLOGIA **22**: 159 there appeared a note on the occurrence of *Peronospora valerianellae* Fuckel. in Arkansas. Prof. J. H. Miller sends a specimen on *Valerianella radiata* collected by him at Athens, Georgia, May 5, 1926. The local station is given as "Hort. Farm," which might lead one to suspect that it may have been introduced, but the Arkansas stations did not suggest that it was not indigenous.—J. J. DAVIS.

Professor Donald Reddick of Cornell University spent May 1st at the Garden examining herbarium specimens of species of *Solanum* and related forms. He has just come from the University of Vermont where he was consulting with Professor Lutman and others. He has recently been delegated by the United States Department of Agriculture to make a survey in Mexico endeavoring to find wild species of potatoes which may be immune to late blight, *Phytophthora infestens*.

The Editor wishes hereby to inform the readers of MYCOLOGIA that nearly half the edition of The North American Cup-fungi (Operculates) has been disposed of. There are many colleges which are offering courses in general botany and mycology which have not yet secured a copy of this work. Since this is the only monograph of this group of plants in America they should avail themselves of this opportunity before the edition is exhausted. A complementary volume on Inoperculates is in course of preparation, but it will necessarily be several years before this can be completed.

Dr. David Miller of the Cawthorn Institution, New Zealand, called on members of the Garden staff, May 2d. Dr. Miller is engaged by the New Zealand Government to make a survey of insects and fungus diseases of *Rubus fruticosus* and other weeds with the hope of finding certain parasites which would be sufficiently destructive to warrant introduction into that country. He was much interested in the three strains of the Gymnoconia orange-rust of blackberries as this seems to be the one parasite most destructive to species of blackberry.

PUCCINIA CARICIS-STRICTAE

Puccinia Caricis-strictae Diet. (Syn.: *Uromyces Caricis* Peck, *Dicaeoma Caricis-strictae* Arth. & Kern) is a peculiar and interesting rust whose aecium is not yet identified. In January Mr. Roy Latham sent me a packet of Long Island, N. Y., collections made during 1929. It included a *Boehmeria* leaf which bore a single aecium in good form. He remembered the identical spot of the collection and on request kindly made a return trip of over 25 miles to the place to seek rusted *Carex* leaves. He found what proved to be *Puccinia Caricis-strictae*. I did not get *Boehmeria* in time this spring to infect it with telial sporidiola but probably some readers of this note may have opportunity this season to make observations or experiments confirming or correcting the suspected connection stated above.—JOHN DEARNESS.